TEA RESEARCH ASSOCIATION

ANNUAL SCIENTIFIC REPORT
1968-69
(1st April 1968 to 31st March 1969)

Published by
Tocklai Experimental Station
Jorhat - 8, Assam, India
1969

TEA RESEARCH ASSOCIATION

ANNUAL SCIENTIFIC REPORT
1968-69

(1st April 1968 to 31st March 1969)

Published by
Tocklai Experimental Station
Jorhat - 8, Assam, India
1969

October 1969

CONTENTS

ANNUAL SCIENTIFIC REPORT FOR 1968-1969

DIRECTOR'S REPORT

(1st April, 1968 to 31st March, 1969)

Organisation :

On the 31st March, 1969 the Senior Staff consisted of :-

Directorate :

Director	...	D. H. Laycock, M. B. E . M Sc., A. I. C. T. A.

Administration :

Administrative & Finance Controller	...	M. K. Choudhuri, B. Com (Cal), A. C. A.
Accounts Officer	...	S Mazumdar, B. Com (Cal), A. C. A.
Station Engineer	...	G. B. Singh, A. M. I. S. E.

Soil Chemistry Department :

Soil Chemist	...	S. K. Dey, B. Sc. (Cal), Assoc. I. A. R. I.

Botany Department :

Senior Botanist	...	D. N. Barua, Ph. D. (Cantab)
Plant Physiologist	...	W. Hadfield, B. Sc. Hons. (Liv).
Plant Breeder	...	H. P. Bezbarua, M. Sc. (Gau).

Agriculture Department :

Senior Agriculturist	...	K. N. Sharma, B. Sc. Ag., M. Sc. (B. H. U), Ph. D. (Mich) U. S. A., Assoc. I. A. R. I
Agriculturist	...	S. C. Barua, B. Sc. (Cal).

Entomology Department :

Entomologist	...	B. Banerjee, M. Sc. (Cal), M. S. (S. Illin), Ph. D. (London), F. A Z., F R E. S. (London)

Mycology Department :

Mycologist	...	G. Satyanarayana, B. Sc. Hons. (Andhra) Ph. D. (Mad), F. B. S.

Pesticide Department :

Pesticide Testing Officer	..	T. D. Mukerjea, B. Sc. Ag.(Alld), Ph. D. (London), Assoc. I. A. R. I.

Biochemistry Department :

Biochemist	...	S. B. Deb, M. Sc. (Cal)

Manufacturing Advisory & Tea Tasting Department :

Manufacturing Adviser & Tea Taster	...	R. Choudhury, B. Sc. (Cal)
Second Tea Taster	...	M. R. Patel.

Engineering Development Department :

Senior Research Engineer	...	D. N. Barbora, B. Sc. Mining (Banaras) M. Sc. Eng. (London) D. I. C.
Second Research Engineer	...	T. C. Barua, B. Sc. Hons (Gau) B. Sc. (Mech. Eng) Banaras, M. Sc. (Manchest), Assoc. UMIST.

Statistics Department :

Statistician	...	A. K. Biswas, M. Sc. (Gau.)

Advisory Department :

Chief Advisory Officer	...	S. K. Dutta, B. Sc. Ag. Hons. (Bom), B. Sc. (Wales).

Assam

South Bank

Advisory Officer	...	P. C. Sharma, M. Sc. (Banaras), Ph. D. (London), F. L. S.
Advisory Officer	...	S. K. Sarkar, B. Sc. (Cal), B. Sc. Ag. (B. H. U.)
Advisory Officer	...	B. C. Barbora, B. Sc. Ag., M. Sc. (Agronomy) I. A. R. I.

North Bank

Advisory Officer	...	H. Mitra, B. Sc. (Cal)

Cachar

Advisory Officer	...	T. K. Ghosh, B. Sc. Ag. (Pat.), Ph. D. (Cornell) Assoc. I. A. R. I.,

West Bengal :

Chief Advisory Officer, West Bengal	...	W. J. Grice, M. A., Dip. Ag. (Cantab)
Advisory Officer, Dooars	...	S. Basu, B. Sc. Ag. Hons. (Delhi) Assoc. I. A. R. I.
Advisory Officer (Darjeeling & Terai)	...	F. Rahman, M. Sc. Ag. (Bihar), Ph. D. (I. A. R. I.), New Delhi

West Bengal Experimental Station :

(*Mal*)	...	N. B. Chanda, M. Sc. (Dac), Ph. D. (Edin).

SENIOR STAFF MATTERS

Transfer : The following Advisory Officers were transferred during the year :-

Name	From	To
Dr. P. C. Sharma	North Bank	Tocklai
Mr. S. K. Basu	South Bank	Dooars
Mr. H. Mitra	Darjeeling	North Bank
Dr. F. Rahman	Dooars	Darjeeling

COURSES

The following Lecture Courses were held during the year :

a) **Field Management Course**

1st Course - 13th - 17th May	28 planters attended
2nd Course - 20th - 24th May	23 planters attended
3rd Course - 27th - 31st May	20 planters attended

b) **Vegetative Propagation Course**

1st Course - 17th - 21st June	26 planters attended

c) **Drainage Meeting**

1st Course - 7th - 11th Oct.	11 planters attended
2nd Course - 14th - 18th Oct.	13 planters attended

d) **Agrl. Sub-Committee Meeting :**
23 rd & 24th Oct. — 13 Members attended

e) **Agricultural Chemical Course**
1st Course - 22nd - 24th July — 26 planters attended
2nd Course - 29th - 31st July — 26 planters attended

f) **Factory Management Course :**
1st Course - 28th Oct. - 1st Nov. — 22 planters attended
2nd Course - 4th - 8th Nov. — 26 Planters attended

TRAINEES

Five employees of different Members gardens, one from a Non-Member garden, one from the Nepal Government and one Tea Board's employee, attended and completed the One Year Training Course. Besides these, nine employees of different Member gardens joined the Short-Term Training on vegetative propagation, out of which seven completed their training. Four who joined this training in 1967 also completed their training during the year.

VISITORS

Some of the Visitors, in addition to local planters who visited Tocklai to seek advice etc. are listed below in chronological order of their visits :

Mr. Toshihiko Hanai, Marukute Ikeura-Cho Anjo-Shi Aichi-Ken, Japan
Mr. Hiroyasu Sugiura, Maeda Hane Okazaki Aichi, Japan.
Mr. Taira Kamiya, Srako, Fukama Snjoshi Sichiken, Japan.
Mr. Satoru Matsushita, Kakoikb Minamiakjo Toyoshi Aichi, Japan.
Mr. R. L. Hards, Chairman, London Scientific Committee, T. R. A., London.
Dr. W. B. Eyton, Sheffield, U. K.
Mr. R. B. Magor, M/s. George Williamson & Co., London.
Mr. G. W. U. Liddle, King William House Group, London.
Mr. A. Goswami, Oil India Ltd., Jorhat.
Mr. Gregory B. Votwa, World Bank, N. Delhi.
Dr. Ralph Lester, Unilever Research Laboratory, Bedford, U. K.
Mr. Ashok Ganguly, Hindustan Liver Ltd., Bombay.
Mr. S. K. Mitra, Esso Standard Eastern, Calcutta.
Mr. J. L. Llewellyn, I. T. A., London.
Mr. Dieter Elz, World Bank, N. Delhi.
Mr. Walter Mackay, M/s. James Finlay & Co. Glasgow.
Mr. I. F. Morriss, M/s. MeLeod Russel & Co. Ltd., London.

Mr. R. A. Collinge, American Consulate General, Calcutta, & Mrs. R. A. Collinge.
Mr. A. F. Macdonald, Chairman, T. R. A., Calcutta.
Mr. Ashok Mitra
Mr. Dharm Narain } Agricultural Prices Commission, New Delhi.
Mr. V. N. Garg. C. S. I. R., New Delhi.
Mr. S. R. Nane, I. C. I. Calcutta
Mr. A. G. Strickland & Mr. R. D. Kennett, M/s. Plant Protection Ltd., U. K.
Mr. Bernard Sachs, World Coffee & Tea, U. S. A., & Mrs. Bernard Sachs
Mr. W. C. C. Gorst, M/s. George Williamson, Africa.
Mr. W. T. Fonseka, Tea Control Dept., Govt. of Ceylon, Colombo.
Mr. R. B. R. Hall, South Australia.
Mr. D. E. Macintosh, James Finlay & Co. Ltd., Kerala.
Mr. R. L. Stone-Wigg, The African Highland Produce Coy. Ltd., Kenya.
Mr. D. R. Emmott of Namingomba T. E., Malawi.
Mr. P. J. Parr, I. T. A., Calcutta.
Mr. S. T. Willatt, A. R. C. of Malawai.
Mr. B. G. Verghese, Information Adviser to the Prime Minister, New Delhi.
Mr. Richard Starr, Australian High Commission.
Mr. M. Gopalkrishna Naidu, D. C., Sibsagar.
Mr. B. K. Mishra, S. P., Sibsagar.
Mr. S. K. Dutta, Chief Justice of Assam & Nagaland.
Mr. & Mrs. D. M. Hacking of Coonoor, S. India.
Mr. Charles F. Brooke Smith, Spring Valley Ceylon.
Mr. H. Ferguson, James Finlay & Co., Glasgow.
Mr. O. A. Bauman, Deputy Asstt. Director, USAID, American Embassy New Delhi, & Mrs. O. A. Bauman.
Mr. R. C. Podol, Chief of the Programme Dvn. USAID, & Mrs. P. C. Podol.
Dr. J. Lewis, Minister Director, USAID, N. Delhi, & Mrs. J. Lewis.
Mr. Amar Singh, Dept. of Afl. Suva, Fiji.
Mr. J. I. Catto & Mrs. M. B. Catto, 10, Somerset Lodge, London.
Mr. J. P. F. Furst, Margherita T. E.
Mr. John Ramsden, Haywards Heath, Sussex.
Mr. J. F. Hay, Supdt. The Moran Tea Coy.
Mr. Peter G. Gordon-Smith-The Moran Tea Co. Ltd., England.
Mr. B. K. Nehru, Governor of Assam.
Mr. W. J. C. Charlier, Macneill & Barry, Group 3.
Mr. Vadachkoria Valery Ivlyanovich- Minister of Food Industry of the Georgian Soviet Socialist Republic.

Mr. Roinishvili Nocolay Yosifovich- Director of the Central Board of Tea Industry of the Ministry of Food Industry of the USSR.
Mr. Abesadze Oter Grigoryevich- Manager of the Georgian Tea Trust of the Ministry of Food Industry of the Georgian SSR.
Mr. Kirvalldze Vakhtang Isidorovich- Technological Dept., Manager.
Mr. Chackviani Gela Kandidovich Interpreter.
Sir Owain Jenkins, Chairman Assam Co. Ltd.
Mr. J. D. Willis, Balmer Lawrie & Co. Ltd.
Mr. R. W. Palmer, Makum & Namdang Tea Co.
Mr. A. K. Roy, Chairman Tea Board.

ADVISORY DEPARTMENT

ASSAM

1. **Extension services**

The demand for extension services increased in all three main districts i. e. South Bank, North Bank and Cachar. Planters not only showed keen interest in regular estate advisory visits but there was a growing interest in meetings organised at intervals in the Clubs of the tea districts, where various field and factory problems were discussed.

The new lecture courses on 'Drainage & Surveying' started during the year were very much appreciated and should help in the better understanding of drainage problems which are acute in so many low lying estates of Assam. Besides the drainage courses, six lecture courses—three on 'Field Management', one on 'Vegetative Propagation' and two on 'Agricultural Chemicals'- were conducted by the Chief Advisory Officer.

Estates which joined TRA recently, generally sought advice on simpler general problems, but the older members wanted advice mainly on specific problems. It is, however, very gratifying to note the rapidity with which the former group passes from the more general problems into the specific.

Recommendations were, on the whole , followed with good results, but exceptions are always present due either to company policy or the poor economic condition of some estates; for example, an estate with no land for extension, hesitates to keep uprooted areas under a rehabilitation crop for our recommended two years.

Routine advisory visits made by the Advisory Officers were as follows :

Areas	Total No. of visits	No. of estates visited
South Bank	239	173
North Bank	151	68
Cachar	78	29

Visits were also made in connection with the conduct of field experiments as follows :

South Bank	—	50
North Bank	—	46
Cachar	—	7

In addition to the visits mentioned above, the Chief Advisory Officer accompanied the Director and the Chief Advisory Officer, West Bengal, on a tour of the Dooars and Darjeeling. He also accompanied Mr. P. A. Browne, the Drainage Expert to 31 estates in Assam. The Chief Advisory Officer also led a delegation consisting of two other Tocklai officers to the tea growing areas in Malawi, Kenya and Uganda, for five weeks in January and February 1969.

2. Crop Outturn

The crops of all districts in Assam were higher than in the previous year. This was primarily due to the favourable weather conditions that prevailed throughout the season except in Cachar where there was a marked drought in the early part of 1968. Unfortunately, in the export market, the average prices realised were not very satisfactory.

3. Field management practices

(a) **Drainage** : Planters continued to take interest in improvement of drainage. There are, nevertheless, estates where old drains have silted up or even if there are few surface drains in sections, the primaries or perimeter drains are lacking to take water away from the area. Indiscriminate planting of old paddy fields to tea, without prior consideration of drainage outfalls, has landed many estates in difficulties. In heavy soils, poor drainage resulted in restricted root growth, with a consequent drop in yield of tea. One of the main problems in several estates, particularly in the South Bank, is lack of good outfalls during the rains. The situation in Cachar has become worse for tea growing on flats, due to silting up of river beds and consequent back flow of water during the rainy season.

In areas having a good outfall, the problems appear to be the wrong alignment of existing drains and insufficient number or inadequate depth of the surface drains. It was emphasised that surface drains should be 90 cm deep, primaries should be 120 cm deep and perimeters at least 150 cm deep. Another problem observed in sandy soils was the caving in of drain sides. This can be avoided by providing correct slopes to the drain sides.

The importance of a grid level survey for preparing contour maps is being impressed upon managements and the necessity for graded contour

drains, both for effective drainage and as a measure against soil erosion, is also being gradually realised whenever new planting or replanting is undertaken.

The Advisory Officers stressed the need to check water tables by means of inspection pits in any area of tea suspected to have poor drainage.

(b) **Pruning cycles** : The majority of estates in the Assam Valley have introduced a three-year pruning cycle, i. e. prune—deep skiff—medium skiff, and the area under skiff has consequently risen considerably. Some estates in droughty areas and without irrigation facilities, have not, however, gone for medium skiff, as damage from drought is apprehended. Besides, some estates which are on orthodox manufacture, have a certain percentage of their estates deep skiffed only and rest is top pruned. Planters are convinced that there is no loss of quality in deep skiffed tea even with orthodox manufacture but they are still not certain about quality of leaf from medium skiffed tea.

Many estates on the North Bank continued to deep skiff at 12.5 cm and to pluck over 7.5 cm of new growth but results were no better than when deep skiffed at 10 cm. and plucked over 10 cm of new growth. Sometimes , deep skiffed tea did not produce good results due to skiffing at a wrong level, at a wrong time or due to too high or poor condition of the frames. Top pruned tea, plucked at 15 cm, when deep skiffed at 10 cm gave poor results as the new wood was generally thin.

In Cachar, prune—deep skiff—medium skiff, or prune—medium skiff—light skiff cycles have been recommended. Many proprietary estates which left tea unpruned earlier have started reverting back to the Tocklai recommended three year pruning cycle. Some of the larger estates are still continuing with unpruned tea and are trying to evolve a four or five year cycle.

It was observed in a drought prone area that shoots in skiffed tea went banjhi just below the normal tipping levels. In such cases, they were advised to remove the banjhis and then to raise the plucking table to the level where bushes would have been normally plucked. In some estates medium skiffed tea had not been properly plucked and the initial tipping level was liberal. This resulted in failure to obtain increased crops from the skiffs.

(c) **Shade** : The species which had been largely used as permanent shade are *Albizzia odoratissima*, *Acacia lenticularis*, *Albizzia lebbek* and *Derris*

robusta. Another species which has been recommended for introduction in permanent mixed stands is *Dalbergia sericea*. Planters have been dissuaded by Advisory Officers from using *A. chinensis*, *A. procera*, *A. lucida* due to high incidence of canker in these species and also *A. falcata* and *C. siamea*.

C. siamea has however been recommended for use as a shelter belt at the bases of hot slopes of teelas in Cachar and the banks of undulating areas in Golaghat.

Indigofera teysmanii appears to grow satisfactorily under most conditions and has been used on a large scale as a temporary shade tree in most estates. In areas, where it is difficult to grow shade, *I. teysmanii* is being recommended for use as a permanent shade on a short rotation of 10-12 years.

Canker caused by *Agrilus beesoni* had been on the increase in *A. procera* and *A. odoratissima*. In young plants, good control has been obtained from the application of Thiodan at 1 in 250 parts of water, or a mixture of lime and dieldrex, to affected parts.

Leaf eating insects were most active on *A. odoratissima*, *A. procera* and *A. lebbek*. Regular spraying at monthly intervals with Thiodan, however, gave good control.

In both the North Bank and the South Bank, *Sternocera aurosignata* grubs caused damage to shade tree seedlings in the nursery and young shade plants in the field. However, those who followed our recommended methods of control of this pest, obtained good results.

Red rust on young shade plants was on the increase and recommendation had been made to paint the stems with copper fungicide mixed with a sticker like Tenac 3-4 times a year starting from May.

To prevent primary root rot infestations, more and more estates are ring-barking shade trees prior to removal from sections of tea

(d) **Cultivation and weed control** : Many estates in the South Bank have used 'Gramoxone', Tafapon and Tafazine in tea areas to control weeds in general and 2,1-D in non-tea areas, mainly to control *Mikania*. In the North Bank also, the area under Gramoxone has steadily increased. In Cachar, some estates have used Gramoxone in all young tea areas whereas others have not yet started using herbicides. Advisory Officers have stressed that financial benefit can be derived from continuous use of herbicides, especially in young tea areas which often cannot be kept weed free. The

main drawbacks to the use of herbicides has been the initial high cost and the difficulties of obtaining Gramoxone. Estates with marginal profits have not been able to use Gramoxone for shortage of funds.

As the soil is left undisturbed while using Gramoxone, an even layer of mulch will be left on the soil and as a result the soil structure will improve. It is likely that feeder roots will grow profusely just below the layer of mulch and this may help in better utilisation of phosphatic fertilisers.

Some weeds like Bagracote (*Borreria hispida*, or Doob grass (*Cynadon dactylon*) appeared to be resistant to Gramoxone.

Damage to the collar of young tea by cheel hoe is common and hand weeding around collars of plants has consequently been advised. Due to faulty cultivation, ridges are often found between rows of young tea. Not only the available phosphate and potash are thereby removed to the ridges i. e. away from the feeding root zone, but in heavy soils tea may more easily suffer from temporary waterlogging. In some estates, depressions around collars of bushes can be observed and this also causes temporary waterlogging. Managements were advised to level the ground in rounds of cultivation.

Planters realise that mulching is beneficial, particularly in very young tea where herbicides are used and the soil remains bare. As this operation is expensive, a lot of progress has not been made to date. But more and more estates are beginning to utilise their wasteland for growing grasses like *Guatemala* for the purpose of mulching.

(e) **Manuring** : Most estates have accepted the revised Tocklai recommendations on manuring i. e. application of 20 kg P_2O_5 and 40 kg K_2O per hectare once in every three years in mature tea. However, not all estates base their nitrogen application on yield and shade density as we normally recommend. Manuring in two doses has been recommended in March and again in May/June, but some estates are applying manure in two equally divided doses, once in September and again in March/April.

In light or medium skiffed tea, if the soil is moist, early application of manure i. e. in the second half of February was advocated.

YTD mixture has been generally applied to young tea but some estates prefer using their own formulae. Our recommendation has been to apply YTD mixture in the first three years, sulphate of ammonia in next two skiffed years and mature tea mixture in the following year.

(f) **Pruning and plucking of young tea :** The standard of pruning of young tea has not been satisfactory in some estates. 'Centering' generally had been liberal and as a result bushes have not spread well. The Advisory Officers have often emphasised the necessity of proper centering in the first two years and in some cases, even in the third year i. e. after deep skiffing.

Young vigorous clonal tea planted in autumn have been pruned in May and June, after starch testing, with good results. If tea is pruned at any other time excepting the January and February period, say in spring or October, planters have been advised to carry out starch testing with iodine.

A series of trials have been started in a number of member estates using a different method of establishment of young tea. The tea is centered within a few weeks or months, following transplanting i. e. as soon as these are clearly established in the field. Thereafter, plucking commences on a lower measure but the plucking level is raised gradually over the next two or three years during which period the tea is not pruned. The preliminary indications are satisfactory but further observations are necessary.

(g) **Other field management practices :** Advice was also sought on nursery techniques (clonal and seed), control of pests and diseases, spacing of tea, green crops and ground cover crops, grasses for soil rehabilitation, maintenance of clonal multiplication plots.

4. Pest and disease control

Red spider continues to be a major pest in some estates in the South Bank, North Bank and Cachar. Those estates which efficiently sprayed prophylactically against red spider using acaricides like Tedion, Ethion and Hexamition remained practically free of this pest. Scarlet mite was reported by a number of estates on the South Bank and there was severe and widespread attacks of purple mites on the North Bank. Tedion, Ethion, Morocide, Trithion and Kelthane gave equally good results for control of these mites when sprayed efficiently.

Looper attacks were reported from both the North and South Banks. There were reports of red slug attacks in the North Bank, of green fly on the South Bank and of helopeltis, aphids and cockchafer grubs in Cachar.

Red rust in young tea is generally on the increase and some of the reasons for its prevalence are inadequate drainage, lack of shade, use of red rust susceptible green crops, general debility of plants in replanted areas and insufficient chemical control. Black rot incidence was heavy in many

estates from July to September on the North and South Banks. The disease could be controlled to a great extent in some estates by regular spraying (prophylactic and palliative) with copper fungicides and by thinning out of shade where it was heavy.

It was observed that in some estates there was a shortage of power sprayers although suitable equipment is readily available on the market. Hence, when there is severe attack of pests like red spider, looper or green flies, a considerable and unnecessary loss of crop occurs. More and more estates are going in for power spraying and often advice is sought on the kind of sprayer to be purchased. For this purpose, a scheme for testing of spraying equipment has been started. However, planters feel that facilities of repairing power sprayers in tea districts are not always adequate. The indigenously manufactured engine that is being used in the majority of the sprayers produced in the country needs constant attention.

Spraying techniques are not always correct and sometimes good results are not obtained because the incorrect concentration of chemicals is used.

The supply position of acaricides like Tedion, Hexamition, Ethion, Kelthane and other pesticides like Thiodan, Telodrin improved during the year. Planters have been advised every month through district 'Pest & Disease' bulletins about the availability of pesticides with local suppliers.

5. New extension, uprooting and replanting

In any estate where land is available for extension, managements have usually gone for extension rather than replanting. The reasons are, 1) uprooting causes a loss in crop for about ten or more years which marginal estates cannot afford. 2) replanted tea does not come into economic bearing as quickly as tea planted on virgin land which we suspect indicates inadequate soil rehabilitation between uprooting and replanting. Where land for extension is not available, estates have taken replanting programmes. It may be mentioned here that estates generally have become keen to uproot old tea areas, after the introduction of the Replanting Subsidy Scheme of the Tea Board. In many cases, however, neither sufficient time has been allowed for rehabilitation of the uprooted land nor deep cultivation like sub-soiling has been done prior to replanting. The growth of tea is expected to be poor in such cases.

In many cases, where subsoiling has been done, it has gone down to about 45 cm only. The Advisory Officers emphasised the importance of using powerful tractors (50 H. P. or more) for subsoiling and stressed that rehabilitation for a period of two years under rehabilitation crops like Guatemala or Pusa Giant Hybrid Napier or *Mimosa invisa* pays in the long

run. In highly acidic soils application of lime has been advocated at 2 tonnes/ha at the time of rehabilitation. This will also help the growth of rehabilitation crops. These suggestions have, however, not been accepted in all cases but where the recommendations have been followed, most encouraging results have been obtained. Many estates, have established nucleus blocks of Guatemala or Pusa Giant Hybrid Napier grasses for multiplication.

In the Assam Valley, replanting has been at the rate of only about 2 per cent of the existing acreage in estates where replanting is a practice, but the proportionate percentage of extension varies a great deal from estate to estate and, therefore, it is difficult to quote an average figure. There has been a growing tendency in Cachar for uprooting and replanting but not much attention has been given to rehabilitation and deep cultivation.

Regular double hedges and staggered double hedges, are gradually becoming popular in flat or gently sloping lands.

In drought prone districts recommendations are being given to use seeds of Manipuri kinds of tea such as Dangri, Rajgarh or polyclonal seed Stock 203 and preferably drought resistant clones such as TV 1, TV 9.

6. Agricultural Machinery

Tractors of 35—50 H. P. are being used for uprooting and preparation of land. In many estates, subsoiling is still being done with tractors of 35—40 H.P. with the result that the depth obtained is only about 35—40 cm, whereas estates using tractors of 50 H. P. or above have been able to do subsoiling to depths of about 60 cm. Tocklai has taken up this matter with the manufacturers in the hope of developing more suitable equipment for subsoiling.

In one of the trials a Fordson Major tractor fitted with a 5—ton Cooke's winch and a Ransomes Trailed Self Lift type subsoiler were used. When the subsoiler was hitched directly to the tractor, the depth obtained was only about 33 cm. but when the subsoiler was pulled in on the winch cable as opposed to the direct hitch, the subsoiler moved in quite easily even when the depth penetrated was the maximum possible for the equipment at 45—48 cm. Encouraged by the trial, a longer subsoiling blade (leg) designed for a penetration of 90 cm, was made locally and fitted to the original wheeled frame of the subsoiler. When the modified subsoiler was hitched directly to the tractor, it could not pull it at all but when the subsoiler was pulled in on the winch cable, the tractor was able to pull easily even when the penetration was down to 84 cm. This trial definitely proved

the point that when a 5—ton winch is used to pull in a trailing subsoiler, a tractor of about 50 H. P. can pull a subsoiler to a depth of about 90 cm.

Sprinklers and other irrigation equipment has been used on a number of estates to irrigate young and mature tea.

In a few experiments on irrigation in Assam Valley, economics of irrigation was studied but these have not indicated irrigation to be economical as far as yield of mature tea is concerned. In drought prone areas, skiffed or unprunned tea definitely benefits from irrigation in terms of early crop. Besides, irrigation no doubt helps in the establishment of young tea.

7. Meetings

Area Scientific Committee : There are three Area Scientific Committees on the South Bank, two on the North Bank and one in Cachar. During the year, a total of 18 meetings were held as under :

South Bank, Area 1	= 3
,, ,, Area 2	= 2
,, ,, Area 3	= 3
North Bank, Area 4	= 3
,, ,, Area 5	= 3
Cachar Area 6	= 3
Joint Meeting of All Area Scientific Committees held in Cachar	= 1
Total	=18

By and large, the meetings were well-attended, especially in Cachar, on the North Bank and in Area 3 on the South Bank.

In addition, attendance at Area 1 meeting has also improved this year but Area 2 continues to be poorly attended. The meetings proved very interesting and useful discussions took place on varied subjects.

The Committee meetings are generally followed by open meetings where all planters of the local sub-areas are invited to join and take part in the discussion. These were also well attended in all areas, excepting Area 2 on the South Bank where there had unfortunately been a lack of general response by the planters. There have been demands for such meetings from the planters in Area 1.

ADVISORY DEPARTMENT—WEST BENGAL

GENERAL

During the year the Advisory Officer in Darjeeling was transferred to the North Bank and the Advisory Officer in the Dooars moved to Darjeeling to take his place. The vacancy caused by the Advisory Officer, Dooars moving to Darjeeling was filled by the arrival of Mr. S. Basu from Tocklai. Dr. N. B. Chanda remained in charge of the Soil Testing Laboratory at Mal and continued on his special assignment of collecting yield and field management data from Member estates.

VISITS

The Advisory Officers who concentrated on routine touring., offered their services to every member estate two to three times during the year. A total of 296 visits were made to 146 Member estates. The total number of Member estates in West Bengal on 31.3.69 was 179, therefore 33 Members did not make use of our services. The table below gives the breakdown of the visits made in each district.

District	No. of visits	No. of member visited	No. of member estates in Dist.
Dooars	162	84	107
Darjeeling	100	47	53
Terai	34	15	19
Total	296	146	179

Out of the 296 visits 39 were made on special request and of these 24 were actually considered of sufficient importance to have warranted a special visit.

The decline in the number of visits made to estates in the year under review over last year is the result of the transfer of the Advisory Officers from and to the Dooars and Darjeeling, coupled with the fact that touring for two weeks came to a complete halt after the floods and landslides in October, 1968. However, it is interesting to note that although the number of visits were less the number of estates visited increased.

In addition to the visits detailed above the Chief Advisory Officer West Bengal accompanied the Director to seven estates in the Dooars and

4 in Darjeeling and Mr. P. A. Browne the drainage expert to 10 estates in the Dooars one each in the Terai and Darjeeling. The Chief Advisory Officer West Bengal also visited the tea growing areas in Malawi, Kenya and Uganda for 5 weeks in January, February, 1969.

It is satisfying to be able to record that our advice has been generally followed and applied in the field. However, there is still a tendency to seek advice on routine pest and disease control. It is considered that, except under exceptional circumstances, it should not be necessary for Advisory officers to detail, in their reports, methods of controlling pests and diseases that are described in the Tea Encyclopaedia and other publications circulated to Members.

It is estimated that under ideal circumstances the Advisory Officers in West Bengal can complete in one year a total of between 330 to 360 visits, with 179 Members this means that if every estate asks for a visit each time the Advisory Officer is on tour, each member could only receive 2 visits a year. Advisory Officers are often asked to go out on special visits outside their normal routine touring. While it is appreciated that emergencies do occur and every effort will be made to accommodate estates with a genuine emergency, often these special requests cannot be considered an emergency. Members will appreciate that if an Advisory Officer is called out on a visit which could easily have waited until the Advisory Officer was on his routine tour, they are wasting the Advisory Officer's time and this may easily result in his routine visits being disturbed. We would therefore be grateful if estates would seriously consider all the circumstances before asking for a special visit.

In general all districts had a fair season, crops were generally below the 1967 level, but were above average. What has been most depressing is the slump in the World price for teas, which has resulted in large quantities of tea being sold at well below the cost of production.

The principal points arising from advisory work during the year are discussed briefly below.

Field Management Practices

(a) **Land Planning :** It is generally accepted in the agricultural world that land planning is a pre-requisite for any agricultural enterprise and the Department has been emphasizing the importance of this subject. It will only be possible to change from extensive to intensive tea planting after each estate has a farm plan showing the catchment areas, soil class and etc. One does not have to tour great distances to see tea planted in

areas that for one reason or another are completely unsuited to tea, with the result that the yield is low, vacancies are high and the area is a constant headache to the manager. A farm plan will show which land is suitable for tea and which is not, where bamboo, thatch and other ancillary crops can be planted and will also indicate where the best areas are for growing food crops for the labour. An accurate farm plan will also indicate the main access roads and drainage lines and the quickest and most accurate method of planning can be done with the use of aerial photographs; these however appear at present impossible to obtain due to security reasons. In the meantime contour level maps are essential for planning and estates have been advised to have these made.

(b) **Drainage :** As reported earlier the Chief Advisory Officer West Bengal accompanied Mr. P.A. Browne, who came to N. E. India to advise on the drainage of the tea areas, on his West Bengal tour and took him to 10 estates in the Dooars and one each in the Terai and Darjeeling. Mr. Browne's tour coincided with heavy rain experienced in late September and early October and it was obvious that a lot is left to be desired in connection with drainage in the plains areas of West Bengal. The main faults appear to be badly aligned field drains, drains not deep enough, drains not of sufficient size to cope with the volume of water, and very poor soil and water conservation measures.

There is no doubt that more importance is being attached to drainage by managers and this topic is discussed a great deal during the Advisory Officer's tours. The Advisory Officers find themselves on a large number of occasions ham-strung while giving advice, for rarely does the manager accurately know the catchment area each main drain is dealing with, and unless this is known, drain designs and capacities have to be left to guess work.

It will not be possible to give thorough advice on this subject untill estates have good contour maps of the whole grant or a farm plan as discussed above, for it is often not appreciated that a system of drains embraces both soil and water conservation and the drainage system must be designed to remove both ground and surface water away from the tea area under control. The general advice given is that drainage system should be designed to remove 2 acre inches per day.

(c) **Pruning Cycles :** In the Dooars and Terai there has been a big swing over to longer cycles, the most popular of which is a three year cycle of light prune, generally followed by deep skiff which is followed by medium or light skiff. In droughty areas a two year cycle of light prune, deep skiff is usually advised and it is interesting to record that a four year cycle

tried in the Terai has given encouraging results. Where the length of the pruning cycle has been increased there has been a general increase in crop providing that adequate steps to control mites and strict attention to the plucking level are taken.

Some estates in the Dooars and Terai have tried what is commonly known as "perennial plucking" this in fact is merely an extension of a longer pruning cycle, the tea is neither pruned nor skiffed and plucked as and when leaf is offered in the dormant months of January and February. Where this is practiced a large increase in early crop is obtained and in addition general overall increase in total crop is anticipated. However, it is expected that the cost of plucking these areas will be higher than other skiffed areas and there is some doubt over the quality of the tea made from unprunned tea on the plains, particularly in the early part of the year.

In Darjeeling there has been a general trend to change onto a longer cycle and there is no doubt that a longer cycle results in a higher crop during the valuable first and second flush period and also in increase in the total crop. It is often difficult to make managers in Darjeeling appreciate that merely increasing the length of the pruning cycle does not automatically result in extra crop. The increase in crop that will be available has to be harvested, and provision must be made for labour in the peak months of April and June. Careful thought has to be given, therefore, before a change in the length of the pruning cycle is undertaken. It is paradoxical that some of the higher yielding estates are on a three year cycle.

(**d**) **Plucking :** Most estates on the plains manage to pluck on a fairly regular round and bring to the factory a standard of leaf suitable to the type of tea commonly made. However, there are occasions when advice on plucking has been given on plains estates, there are the odd cases where the tea has been plucked either too hard or too leniently and both these faults lead to a loss in crop. It is stressed that it is important to appreciate that with the general change to longer cycles a full 18-20 cm plucking measure should be given after the prune so that it will be possible to skiff at the correct levels during the cycle. It has also been necessary to advise the leaving of a leaf after a pest and disease attack such as red spider and and black rot, for some managers continue to pluck at the same level following such attacks.

In Darjeeling on the other hand the general fault is that leaf is not harvested when ready with the result that there is a general rise in the plucking table and this is followed by a loss in crop. This point was stressed in the Annual Report for 1967/68 and no apologies are offered for repetition. There is one sure way of reducing the cost of production and that is to

increase crop. Darjeeling has a bigger potential for a drammatic increase in crop than any other district and plucking on a regular round is one of the biggest factors in this respect. There is a chain reaction when tea in Darjeeling is not plucked when ready; first the fact that it has not been plucked results in leaf being left on the bush and this in itself reduces crop, also the fact that leaf has been left tends to make the bushes go prematurely banjhi and this further reduces crop. Active flushing will only take place after the removal of the banjhi shoots and an effective way of doing this is skiffiing immediately after plucking. The Advisory Officer in Darjeeling has been advising this type of skiff for several years now and it has almost become a standard practice on estates where plucking has got out of hand.

(e) **Shade :** *Albizzia odoratissima* continued to be the most difficult species to establish on the plains area because of its proneness to continuous attacks of various pests and also red rust, Advisory Officers are discouraging the use of this species. The following species have been observed to be comparatively free of pests and red rust, and therefore have been recommended.

1. *Acacia lenticularis*
2. *Derris robusta*
3. *Dalbergia sisoo*
4. *Dalbergia sericea*
5. *Albizzia lucida*
6. *Albizzia lebbek* (in the foothill areas)

Indigofera teysmanii continued to be the most popular temporary species.

In view of the susceptibility of most shade tree species to attacks of various pests, it has now become imperative to undertake pest control measures on an intensive scale from the nursery until the trees are four years of age or are found to be growing well in the field. It has generally been observed that if the shade trees get a good start, they can overcome attacks of pests later. The general opinion of managers is that effective pest control measures are not possible, economically or physically, once the trees become mature.

Shade establishment is undoubtedly more difficult in replanted tea areas than areas planted in virgin soil. One possible reason could be the high soil acidity in replanted areas, and therefore application of lime at the rate of 0.5 kg per pit at the time of transplanting has often been suggested, in addition to cattle manure, superphosphate and wood ash. The importance of digging at least 90 cm deep pits has also been emphasised.

In general the establishment of shade in Darjeeling is not a problem. It is unlikely that shade is necessary above about 2000 feet due to the lower temperatures and hybrid nature of the tea. At the lower elevations shade is often inadequate but the common shade *A. chinensis* is usually easy to establish and with a little effort there is no reason why shade in the low elevation areas should be a serious problem.

Shelter belts can conveniently be discussed under this heading and there is no doubt that there are tea areas in the Terai and Dooars which would benefit a great deal from the establishment of tree shelter belts across the general direction of the hot dry winds which are common in spring. Advice on shelter belts has been given, but normally no action is taken.

(f) **Vegetative Propagation :** As many requests were received for advice on the techniques on cleft grafting 8 demonstrations were arranged in the Dooars one in the Terai and several in Darjeeling. The demonstrations in Dooars and Terai were divided into two parts the first part consisted of a short talk illustrated with coloured slides and the second part was practical work in the field and all attending had the chance to prepare a stock tree, the scion and do the grafting. A total of 86 planters attended these demonstrations. It is appropriate here to thank the managers of all the estates who so willing provided facilities for these demonstrations, without their kind co-operation the arrangement of these demonstrations would have been very much more difficult. Two estates in the Dooars are converting *jat* seed baris into clonal seed baris by cleft grafting, advice on techniques etc. have been given to these estates from time to time. Many estates are using the technique of cleft grafting for the rapid multiplication of clonal material, and a number are having very good success.

Routine advice on all aspects of V. P. work is a common feature during Advisory Officers' tours. By and large there is a big upsurge in interest and most managers are doing their utmost to reach a position where they can do all their planting with clonal material. Estates in Darjeeling and the Terai are generally behind, but there has been general increase in interest shown in V. P. work.

(g) **Fertilizers :** There are a number of estates who have not yet followed the recommendation of applying P & K at the rate of 20 kg P_2O_5 and 40 kg K_2O per hectare in addition to the normal dose of nitrogen to one third of the estate per year in spite of continuous advice to do so. The level of nitrogen applied is between 80-120 kg N/ha over most of the Dooars and Terai and there is a general tendency for the level of nitrogen to increase. The same is true in Darjeeling for there appears to be a slow

break down in the widely held belief that high levels of nitrogen reduce flavour. There is however room for a general increase in nitrogen application in Darjeeling, but this is coupled with the ability to harvest the increase in crop at the the correct time — there is no point in increasing the nitrogen level if it is not possible to harvest the extra crop.

Foliar application of urea on young tea and nurseries is becoming more widespread and advice on methods of applying urea by this method and concentrations to use was often given.

(h) **Infilling :** There are large areas of tea in the Dooars and Terai that have a high percentage of vacancies and these vacant areas are undoubtedly holding back the yields. The Advisory Officers have advised the intensive infilling of such areas not due for uprooting in the next 8-10 years time. The subject of infilling was discussed in detail in a Dooars Area Scientific Committee meeting at which members detailed their experiences. Generally satisfactory results in respect of an increase in yield can be expected from infilling, but doubt was expressed over the use of vigorous clones as infills due to the fact that clonal tea needs closer supervision when young compared to young seedling tea. An experiment covering a wide range of soil and climatic regions on infilling has been laid out, and the results of this experiments should answer the complete economic question of infilling.

(i) **Cultivation & Weed Control :** Drought during the cold weather is a common feature in most districts in the Dooars and Terai and therefore emphasis has been made to direct all cultivation work towards moisture conservation from October, when the soil profile is expected to be fully moist. Apart from mulching and keeping the ground weed free, thinning out of heavy green crop shade before the onset of the drought has been recommended. It has been pointed out that a heavy green crop can produce droughting effects far outweighing its value as a shade.

Chemical weed control in the Dooars and Terai is getting more and more popular and at least one garden reported a significant increase in yield in the very first year of Gramoxone application. Some estates in Darjeeling have tried controlling weeds with Gramoxone with some success, but it has been advised that they should proceed slowly in this direction, for it is certain that soil erosion is kept in check in Darjeeling estates by the normal practice of keeping weeds under control by sickling. Soil erosion in several Dooars estates was seen following the complete control of weeds by chemicals, wherever this has occurred the tea had been planted with the rows running up and down the slope. A warning has been issued to make sure that sufficient physical structures are present to prevent erosion before complete control of weeds is resorted to by chemicals.

(j) Mulching : Managers are becoming more and more conscious of the need for mulching for protection of soil from the deteriorating forces, conservation of soil moisture and improvement of the physical condition of the soil. It is a very expensive and labour-consuming operation, but considering the tremendously beneficial effects of mulching, ways and means must be found to carry out mulching, especially in young tea areas where the soil cover by the tea bush itself is still incomplete. In most estates, plenty of green jungle is available close by, but it is usually the question of availability of labour. It has been suggested that estates plant out Guatemala and Pusa Giant Hybrid Napier grasses in all odd unutilised corners of the estates with a view to getting material for mulching. It is expected that with the gradual introduction of labour-saving devices such as the use of power sprayers and the use of weedicides, more labour could be released for dressing areas with mulch.

Pests and Diseases

(a) Pest & Disease Bulletin : Estates in the Dooars and Terai regularly received advice on pest and disease control throughout the year through the circulation of the monthly "Pest & Disease Bulletin". This has continued to prove a useful guide and most managers admit that they read it and use it for reference purposes. A pest and disease bulletin has been started in Darjeeling and while the completion and return of the proforma has proved disappointing, the report circulated has been acclaimed, it will have more general application as soon as replies to the proforma are received from more members.

(b) Red spider : There was a serious attack of red spider all over West Bengal in April/May 1968 and the attack was the worst for a number of years. It was obvious that on estates where adequate prophylactic treatment had been given, the attack was kept in check. The Advisory Officers consider that there is no need for any estates to suffer a severe attack of red spider, or any other mite or insect pest, for there are plenty of good pesticides and acaricides on the market and power sprayers are now easily available.

It is generally found that where there has been a bad attack of one pest or another that one of the following faults has been the cause :- (i) inefficient spraying, (ii) spraying with the wrong chemical, (iii) insufficient spraying machines on the estate, (iv) spraying after the pest has become established and (v) lack of attention to detail.

(c) Cost of Pest & Disease Control : It has been stressed again and again that money spent on spraying equipment and pesticides is money well spent and is certain to pay off handsomely in the long run. It was

obvious that the amount spent on the control of pests and diseases varied a great deal amongst members. A questionnaire was, therefore, sent to 30 Members estates in the Dooars asking them to indicate the amount spent on pest and disease control during 1965-67. The survey was a crude one but nevertheless it indicated some interesting results. The per hectare expenditure on individual estates varied from Rs. 2.00 to Rs. 70.00 in 1965, Rs. 3.00 to Rs. 79.00 in 1966 and Rs. 7.00 to Rs. 84.00 in 1967. There were indications that where expenditure on this account was much less than Rs. 40.00 per hectare, the control of pests and diseases had not received the attention that it deserved. Such estates should be prepared to spend anything upto Rs. 80.00 per hectare for a few years to ensure proper control after which the recurring expenditure is likely to stabilise at a level between Rs. 30.00 and Rs. 40.00 per hectare.

(**d**) **Defoliation :** The 1968 results of the long term defoliation trial in the Dooars showed that although defoliation of deep skiffed tea results in a good control of red spider it leads to a loss in crop of some 200 kg made tea per hectare. Recommendations to estates that defoliation of deep skiffed and light pruned tea should not be necessary have been given for sometime and although some estates have stopped defoliation others continue to defoliate, if for no other reason than to find work for their labour. There must be plenty of work on an estate that the labour could do that will not result in a 200 kg/ha loss in crop at the time defoliation is usually done and one immediately springs to mind- MULCH.

(**e**) **Other Pests :** There are a host of other pests attacking tea and the Darjeeling Advisory Officer has to cope with more than his fair share, it is very rare to see a report on a visit written by the Darjeeling Advisory Officer where no mention is made of pests and diseases. Amongst these are :-

Cerambycid borers, thrips, green flies, and scale insects.

(**f**) **Cerambycid borers** are causing considerable damage in some estates, old age and root exposure seem to be the two main factors responsible for the increased incidence of these root borers. (ii) *Thrips* every year attack both pruned and skiffed tea and so cause a loss in crop this fact is now appreciated by more managers and there is more effort made to control thrips than in the past, (iii) *Green flies* continue to reduce the second flush because of the general belief that their attack ensures better quality teas. There is no scientific evidence to prove this contention and in fact there is evidence to show that an attack of green flies do not improve the quality. (iv) *Scale insects* are a major pest and the damage they do is insidious, this point is now more generally appreciated and a more concentrated effort is being made to control these pests.

Both in the plains areas as well as Darjeeling scarlet and purple mites are found. Scarlet mite attack in the year under review was not as serious as in the past. Looper and red slug caterpillars did some damage in certain areas, but were brought under control.

(g) Diseases : Red rust continues to be the most important disease in the plains areas and there is no young tea that can boast complete freedom from this disease. Blister Blight in Darjeeling leads to a loss in crop every year in spite of the fact that its control is fairly simple. Black rot on the plains is also a disease that causes loss on some estates. All the primary root rots were found but where the recommended steps were taken these posed no problem. *Aglaospora* is still a serious stem disease in Darjeeling and the only way of keeping in check appears to be heavy and low pruning and where these prunes have been done well, the disease has usually been kept in check.

Extension, Uprooting and Replanting

As a result of the Tea Board's decision to subsidise replanting, it is reasonable to expect that the replanting work will be stepped up in all areas in the near future. Poorly rehabilitated replanted tea areas are a continual source of worry to Advisory Officers and, therefore, there is an urgent need to persuade managers to take proper rehabilitation measures in uprooted areas before replanting to forestall future disappointments. Gardens have been urged to take advantage of the recently introduced grasses such as Guatemala and Pusa Giant Hybrid Napier which are excellent for the purpose of soil rehabilitation. *Mimosa invisa* cover crop is also a very useful rehabilitation crop and seeds are readily available.

The importance of subsoiling in areas due for replanting is also being realised but subsoiling to a depth of 90 cm, which is Tocklai's standard recommendation, is impossible to obtain with tractors and subsoilers normally used by estates. However, all possibilities are being explored by Tocklai to surmount these difficulties.

In Darjeeling the extent of replanting is very small and is mainly confined to the financially stable estates that have proved clonal material available.

Extension is confined to those estates where land is available and is being forced on some estates for fear of unlawful encroachment. It is sometimes believed that because the young tea has been planted on virgin soil some of the finer points of management can be overlooked. Nothing could be farther from the truth and these facts are stressed on tours.

4th/5th October, 1968

The story of the disaster in Darjeeling on the 4/5th October 1968 starts at 3.00 p. m. on the afternoon of the 2nd October. The automatic rainfall recorder in the meteorological station at Nagri Farm T. E. recorded rainfall as follows :- 3 p. m. on the 2nd to 8.30 a. m. on the 3rd October 3.60 inches, 8.30 a. m. on the 3rd to 8.30 a. m. on the 4th October 10.24 inches and 8.30 a. m. on the 4th to 5.30 a. m. on the 5th October 15.07 inches with 9 inches falling between 6 p. m. and 1 a. m. It is obvious from these figures that the rain was gentle to start with and slowly built up to a treamendous intensity over the 62 hour period of continuous rain. The net result of this continuous, unprecedented rainfall was that the already saturated soil was unable to hold more water, and land slides occurred over the whole of the Darjeeling district causing untold damage to roads, culverts, flume lines, houses, villages and even factories. Over 1000 ha of tea was either lost or buried, which is equivalent to six medium size hill estates, over 150 lives were lost and in addition one factory was destroyed and many others have been either damaged or rendered unsafe.

In spite of the tremendous rise in the water level in all rivers little damage to tea in the Dooars was recorded, but the loss of life, both human and livestock, was fantastic.

As soon as it was possible the Director and specialist officers from Tocklai visited Darjeeling to see what assistance the TRA could give to members. The resident Advisory Officer walked many miles and climbed up and down many hills to give on the spot advice. As a gesture of good will the Chairman TRA agreed to supply rehabilitation grasses and cuttings of Tocklai clones to Member estates in Darjeeling who suffered in the disaster at a reduced price.

At the time of writing (May 1969) most of the estate roads have been remade and communications are back to normal, but there is a real fear that if rainfall is heavy and intense at any time during the coming monsoon further damage will be done. As far as production is concerned it is the belief of the Advisory Department that, providing climatic conditions are not unduly unfavourable, the District as a whole should harvest much the same crop as in 1968 for the crop lost from the 1000 ha washed away can easily be made up on other areas by more intensive management, i. e. better plucking, good pest and disease control, extra nitrogen and etc.

Yield Survey

As mentioned at the beginning of this report, Dr. N. B. Chanda has been collecting yield and field management data from Member estates.

He completed the survey for 50 estates in the year. Brief details are that yield figures for the 15 years ending 1966 for each section are being tabulated along with management practices and rainfall data. The object of the survey is to find out the factors that lead to an increase or decrease in yield and the magnitude of the increase or decrease. The mass of data will have to be analysed before any conclusions can be reached and it is hoped that these conclusions will form a very useful guide for advisory recommendations and planning of future experiments.

While firm conclusions will have to wait until the analysis is complete, it is interesting to record some observations already made.

(a) **Yield increase and Nitrogen fertilizers :** The average overall increase in yield for the 15 year period of the estates surveyed is only 366 kg/ha. The highest average yield of the highest yielding estate was 2130 kg/ha and of the lowest yielding estate was 988 kg/ha. The increase in yield over the 15 year period is associated with the increased use of inorganic nitrogen which is now between 68-112 kg N/ha.

(**b**) **Replanting & Rehabilitation :** Inadequate rehabilitation was given in all replanted areas, replanting being done within 8-10 months of uprooting, in some cases replanting was done 3-4 months following uprooting. No estate subsoiled between uprooting and replanting. By and large the yield of the replanted tea is disappointing and is only a little better than the yield of the uprooted tea.

(**c**) *jats* : Most of the new planting whether extension or replanting is done with light leafed *jats*. Some clones have been used and one group has planted a considerable amount of Stock 203.

(**d**) **Records :** In general the records kept by the estates were satisfactory except for details of cultivation and vacancy counts.

MEETINGS

The Chief Advisory Officer, West Bengal paid four visits to Tocklai and the other Advisory Officers and Dr. Chanda one visit each.

The following annual general meetings were attended : Dooars Branch Indian Tea Association by Advisory Officer, Dooars,

Darjeeling Branch Indian Tea Associaton by Chief Advisory Officer, West Bengal and Advisory Officer, Darjeeling,

Tea Association of India, by Advisory Officer, Dooars, North Bengal Branch,

Indian Tea Planters' Association by Dr. N. B. Chanda.

The Chief Advisory Officer, West Bengal attended two meetings of the T. R. A. Agricultural Sub-Committee. The three Area Scientific Committees in Bengal held a total of 9 meetings, the Dooars and Terai Committees met twice and the Darjeeling Committee 4 times in addition there was a joint meeting between the Dooars & Terai Committees. Meetings when possible were arranged to coincide with visits of Tocklai Officers to Bengal, there was always a free exchange of ideas and all meetings proved extremely helpful and improved the liaison between the planter and scientific staff. The Advisory Officer Dooars, two Dooars members and 2 Darjeeling members attended the joint meeting in Cachar and all reported what a success this joint meeting had been. The suggestion has been made that the next joint meeting be held in Bengal, this would be welcomed and suitable plans will be made.

The Chief Advisory Officer West Bengal also attended meetings of the 3 South Bank Area Scientific Committees during his visits to Tocklai.

EXPERIMENTS

Experiments and other work at Nagrakata Head Quarters

Nagrakata Head Quarters

Work in the plots at Nagrakata came to a standstill due to a walk out of the temporary labour in July. It took about one month to get work back to normal following the walk out. Two blocks of an agricultural trial on clones were planted. 15 Tocklai clones, 2 new clones from Mal and Stock 203 standard are being tested in this trial. The other two blocks, planted in 1967 have grown well.

A trial on cleft grafting was continued in the Jiti seed bari with the object of confirming the results obtained in 1967. Unfortunately the polythene bags were stolen from several treatments and so no conclusions could be made.

A trial of composite and complete plants was planted out during the year. Grafting had been done in the nursery and it will be interesting to see the root scion interaction, for root stocks differ in their susceptibility to drought.

Nearly 5 acres of seed bari was planted. The seed bari is biclonal and will produce seed suitable for Darjeeling. An experiment has been laid out in the seed bari having the following object :- to see if composite plants produce more seed than complete plants and to see if grafting in the nursery is superior to grafting in the field and if the root stock has any bearing on the seed yield of composite plants.

A small trial was planted to compare the affect of 9 grasses *Mimosa invisa*, Bagracote jungle and bare soil on the aggregate status.

15 kg of seed of each of the following stocks were planted in tubes : 449, 450, 397 and 206. Plots of these biclonal stocks will be established at Nagrakata for demonstration.

Nearly 1,18,000 cuttings of Tocklai release clones were distributed to Member estates in the year. This is a big increase over last year and is attributed to the fact that there was a big reduction in prices of clones released over 6 years ago. There was a big demand for 19/29/13 and 106/1. Over 160 scions of TV14 and TV16 were released to one estate and about 6,500 scions of the seven clones making up the Stock 203 poly-clonal bari have been released to one estate who is converting their *jat* seed bari.

Guatemala, Pusa Giant Hybrid Napier and Weeping Love Grasses were released to Member estates. Just over 4,000 cuttings and 600 stems of Guatemala grass, 3,700 cuttings and 550 stems of Pusa Giant Hybrid Napier grass and 240 clumps of Weeping Love Grass were distributed.

Clonal Proving Station, Darjeeling

(a) Trial Planted 1967 : Observations were made on the growth of the 19 clones in this trial and they were managed with the object of obtaining leaf as soon as possible. Generally the growth and development of all clones has been good.

(b) Trial Planted 1968 : A second trial was planted in which 8 clones are being tested against the Nanda Devi standard, 3 of these clones are Tocklai release clones, one clone comes from an upper Assam estate and the remainder from Darjeeling estates.

(c) Factory : Towards the end of the year a start was made on the construction of a miniature factory and quarter for the field assistant. The plan is to have the factory completed so that leaf can be manufactured from July, 1969.

The Chief Advisory Officer West Bengal paid a total of 8 visits to the Clonal Proving Station during the year.

Field Experiments on Estates

Short and long term experiments are in progress on Member estates covering a number of projects, such as cultivation, shade, manuring, pruning, plucking, rehabilitation of soils, irrigation, clonal seed, reclamation, pruning, plucking, rehabilitation of soils, irrigation, clonal seed, reclamation of subacid soils, infilling and pests and diseases control. A complete list of Advisory Dapartment experiments appears in Appendix A, and a list of experiments being conducted in co-operation with other departments is given in Appendix B. The Chief Advisory Officer West Bengal paid 86 visits to these experiments. Brief details of the distribution of these experiments are detailed below :

(a) **Dooars :** In the Dooars there are 24 Advisory Department experiments and 15 experiments conducted in co-operation with other Departments.

(b) **Terai :** In the Terai there are 3 Advisory Department experiments and 2 experiments conducted in co-operation with other Departments.

(c) **Darjeeling :** In Darjeeling there are 14 Advisory Department experiments and 6 experiments conducted in co-operation with other Departments.

MISCELLANEOUS

Soil Testing

A total of 6,240 soil samples were analysed during the year and of these 1,832 were for experiments.

Visitors

As usual a large number of visitors visited the Headquarters during the year.

Building & Land

About 12 acres of land was acquired from Nagrakata T. E. on the West of the P. W. D. road opposite the bungalows and plots. This land was fenced and apart from the Darjeeling biclonal seed bari is earmarked for building development. Servants' quarters for the two existing bungalows were constructed on the newly acquired land during this year.

A new pump and engine were installed in a pump house in the Sukhani Jhora and this arrangement has greatly eased the water supply. At no time in the 1968/69 dry weather was the Headquarters short of water. Piped water was connected to the staff quarters.

Three staff quarters were built for outstation field assistants, one in the Terai, one in Dam Dim and one in Jainti Sankos Sub-districts.

Meteorological Stations

Two fully equipped meteorological stations are maintained in West Bengal, one at Nagrakata Headquarters and the other at Nagri Farm T. E. in Darjeeling. Regular readings were kept throughout the year and a Spore Trap was installed by the Mycologist in the Nagrakata Station early in 1969.

SUMMARY OF RESULTS
ADVISORY DEPARTMENT FIELD EXPERIMENTS

Brief summaries as at the 1st of April 1969, of some of the experiments conducted by the Department in member estates, are given below.

Irrigation

North Bank, Assam

In one experiment on irrigation-cum-pruning (AN 74— Assam kind of tea, loamy soil) conducted during 1967, irrigation increased the total seasonal yields significantly. Unpruned tea, whether irrigated or not, gave significantly more crop than July and December deep skiff with and without irrigation. In another similar experiment in 1967 (AN 75 — Tingamira, sandy loam soil), irrigation made no difference to unpruned tea but resulted in a significant increase in yield in the case of December deep skiff.

South Bank, Assam

In one experiment on irrigation-cum-pruning (AS 68-Assam kind of tea, heavy soil), the results obtained in 1967 showed that the main effect of irrigation was not significant and it did not even show an increase in early season crop. This may be due to 416 mm of rainfall that was received between February-April. In this experiment, unpruned tea gave a significantly higher crop than July deep skiffed tea but failed to show any significant increase over December deep skiff whether irrigated or not.

Nitrogenous fertilisers

1) High frequency application of sulphate of ammonia : Several experiments were in progress to study and compare the effects of single or high frequency applications of different levels of nitrogen on the yield of tea. The levels of nitrogen varied from 100 kg to 250 kg/ha, applied in a single dose or in 4-8 equal monthly doses. Results of some of these experiments are described below :

South Bank, Assam

In two experiments AS 62 (Doolia *jat*, loamy soil) and AS 64 (Assam kind of tea, loamy soil) there was no significant increase in crop in 1968 from doses higher than 100 kg and 112 kg N/ha and no benefit could be obtained from divided doses in comparison with single whole applications. In another experiment AS 56, (Khorijan *jat*, sandy loam soil) similar results were obtained in 1968. Tea was deep skiffed in AS 62, top pruned in AS 64 and levelling off skiffed in AS 56.

In experiment AS 69, (Assam kind of tea, heavy soil), the levels higher than 100 kg N/ha failed to give any significant increase in yield in 1968 and there was no gain from divided doses. The economics of manuring is shown in the Table 1.

Table 1 : Yield of made tea in kg/ha and economics of manuring for the season, 1968.

Treatments	Yield	Cost of fertiliser in rupees	Cost of application @Rs. 12.50 per ha, per application	Total cost in rupees	Net financial returns on the basis of marginal return of Re. 0.50, Re. 1.00 & Rs. 2.00 per kg of made tea		
					Re. 0.50	Rs. 1.00	Rs. 2.00
T_1. 100 kg N/ha	3209	250.00	12.50	268.50	1336	2940	6149
T_2, 150 kg N/ha	3322	384.00	12.50	396.50	1264	2925	6247
T_3, 200 kg N/ha	3177	512.00	12.50	524.50	1064	2652	5829
T_4, 250 kg N/ha	3190	640.00	12.50	652.50	942	2537	5727
T_5, 25 kg×4 = 100 kg N/ha	3209	256.00	50.00	306.00	1298	2903	6112
T_6, 30 kg×5 = 150 kg N/ha	3301	384.00	62.50	446.50	1204	2845	6155
T_7, 33.33 kg×6 =200 kg N/ha	3159	512.00	75.00	587.00	992	2572	5731
T_8, 31.25 kg×8 = 250 kg N/ha	3259	640.00	100.00	740.00	889	2519	5778
L.S. D. (P=.05)	N. S.						
C.V%	6.7						

The net financial return of different treatments showed that there was no significant gain from increasing the dose of nitrogen above 100 kg N/ha or from split applications. However, when the marginal return was Rs. 2/-, there was a gain from 150 kg N/ha when applied in one single dose over 100 kg N/ha.

North Bank, Assam

In experiment No. AN 59 (Doolia & Khowang *jats*, red bank soil), the results in 1968 when the tea was medium skiffed, were the same as experiment Nos. AS 62 and AS 64.

Cachar , Assam

In experiment No. C. 29 (Chumoljan *jat*, loamy soil), the results obtained in 1968 were the same as the North Bank experiment. Tea was unpruned as in the previous year.

N. P. K. Manuring

South Bank, Assam

In one experiment (AS 34-Doom Dooma & Khorijan *jats*, sandy loam) the effect of using Phosphorus (P) at two levels i. e. 11.25 and 22.5 kg/ha and Potash (K) at 22.5 kg/ha in combination with 112 kg N/ha was studied for six years (1962-67). In none of the years did the application of phosphate or potash increased the crop significantly. The data are shown in the table 2.

Table 2 : *Yield of made teas in kg/ha* (1962–67)

Years / Treatment	1962	1963	1964	1965	1966	1967	Mean
$N_{112}\ P_0K_0$	2648	2261	2483	2060	2641	2268	2394
$N_{112}\ P_{11\cdot25}\ K_0$	2447	2160	2454	1988	2591	2497	2356
$N_{112}\ P_{22\cdot5}\ K_0$	2497	2253	2433	2060	2461	2361	2344
$N_{112}\ P_0\ K_{22\cdot5}$	2562	2232	2605	2117	2734	2469	2453
$N_{112}\ P_{11\cdot25}\ K_{22\cdot5}$	2540	2261	2555	1995	2705	2576	2439
$N_{112}\ P_{22\cdot5}\ K_{22\cdot5}$	2548	2339	2555	1938	2605	2519	2417
C. V%	6.4	6.6	4.6	6.7	4.2	5.9	

Differences not significant.

N. P. K. Manuring on young tea

This experiment (AS 44-Planted in 1955 with Betjan *jat*, sandy loam soil) was started in 1964 to study the effect of different doses of phosphate and potash with a constant dose of nitrogen (112 kg/ha) on replanted tea. It is interesting to find that the treatment with $N_{112} P_{224} K_{224}$ continued to give the highest yield in 1968 although application was made in the first two years of the experiment only i. e. 1965 and 1966. The residual effect of high doses of P and K was present even though applications of P and K have been discontinued since 1967.

Superphosphate vs. Rockphosphate on green crops

North Bank, Assam

In one experiment on red bank soil conducted during 1967, superphosphate (16% available phosphate all of which is soluble in water) and rockphosphate (30% available phosphate all of which is insoluble in water) were used in drills before sowing seeds of *Crotalaria anagyroides*. Superphosphate was used at 450 g and 900 g per 12.2 running metres and rockphosphate at 240 g and 480 g per 12.2 running metres. The heights of the plants were measured after three months from sowing. It was found that there was no significant difference between treatments i. e. rockphosphate was found to be as good as superphosphate in accelerating growth and that higher doses had not significantly increased the height of plants. The use of either superphosphate or rockphosphate increased the heights of plants significantly over no fertiliser.

Soil Rehabilitation

The following experiments clearly demonstrate the great importance of rehabilitating soils after uprooting old tea and before replanting with the new.

North Bank, Assam

It was observed in 1968 in experiments AN 46 (clayey loam soil) and AN 47 (loamy soil) that in the early stage of growth of replanted tea in uprooted areas, previous subsoiling and deep ploughing were more beneficial than no subsoiling and no deep ploughing. It was also found that green cropping for two years preceding replanting was more beneficial than no green crop or green crop for one year only.

South Bank, Assam

In experiments AS 45 (heavy soil), AS 48 (sandy loam soil) and AS 49 (heavy soil) similar results to the above were observed during 1968.

Dooars

In one experiment D 28 (loamy sand soil) in 1967 ploughing and subsoiling produced better plants when compared to no ploughing and no subsoiling. It was also observed that the vigour of plants was in direct proportion to the length of rehabilitation cropping. Two years rehabilitation was better than one year and one year was better than no rehabilitation. Similar results were obtained during 1968 in another experiment D. 27 (loamy sand soil).

Soil Climatological Survey

A number of experiments were started in 1962 to study the growth of different kinds of tea under widely varying soil and climatic conditions and also their responses to different levels of nitrogen.

Five clones i. e. TV 1, TV 2, TV 3, 107/4 and 3/22 were used combined with nitrogen levels at N_0, N_{55}, N_{110} and N_{165} kg /ha. Results of a few experiments are given below.

Dooars

In experiment No. D. 24 (heavy soil) the main effects of nitrogen and of clones, and the interaction between clones and nitrogen levels were found to be significant in 1968. All levels of nitrogen gave significantly higher yields than no nitrogen.

Clone 107/4 gave a significantly higher yield than the rest of the clones. Clones TV1 and 3/22 produced significantly higher crop than TV2 and TV3. There was no significant difference in yield between clones TV1 and 3/22 and between TV2 and TV3.

Clone × Nitrogen interaction. Yield of made tea in kg/ha (1968)

Clone / Nitrogen	TV1	TV2	TV3	107/4	3/22	Means
N_0	1455	1200	1109	1764	1418	1389
N_{55}	1800	1436	1473	2418	1782	1782
N_{110}	1891	1546	1618	2982	1673	1942
N_{165}	2073	1746	1546	3109	2055	2106
Means	1805	1482	1436	2568	1732	

L. S. D. (P = . 05)	between individual figures		= 260
,, (P = . 01)	,,	,,	= 350
,, (P = .001)	,,	,,	= 462
C. V%			8.7

L. S. D. (P = . 05)	between clone means	= 130
,, (P = . 01)	between clone means	= 175
,, (P = .001)	between clone means	= 231
C. V%		8.7

L. S. D. (P = . 05)	between nitrogen means			= 64
,, (P = .01)	,,	,,	,,	= 96
,, (P = .001)	,,	,,	,,	= 155
C. V%				0.8

Generally, the yield of all clones progressively increased with the increasing doses of nitrogen except for clones TV 3 and 3/22 where increasing the dose from N_{110} to N_{165} and N_{55} to N_{110} respectively failed to cause more crop.

Cachar, Assam

In experiment C. 20 on plateau (loamy soil) with exactly the same treatments, the results obtained in 1967 showed that 165 kg N/ha caused significantly higher yields than both 110 kg N/ha and 55 kg N/ha. There was no difference between 110 kg N/ha and 55 kg N/ha but both gave higher yields than no nitrogen.

Clone 107/4 yielded significantly more than all the other clones. Clone 3/22 gave highar yields than TVI or TV3 but there was no defference between TV1, TV2, TV3.

There was no intcraction betwcen nitrogen levels and clones.

Darjeeling

In the Darjeeling experiment of this series Dj. 19 (loamy sand soil) conducted during 1967, owing to a high percentage of mortalities and a variation of age of plants between the replicates, the coefficient of variation was very high and therefore, the results are not very reliable.

However, clone 107/4 gave significantly higher yield than all other clones.

Liming

North Bank

In experiment No. AN 80, (Tingamira *jat*, sandy loam soil), liming in 1968 at the rate of 1-2 tonnes/ha again failed to produce any effect on the yield of tea in acid soils of pH value below 5, when nitrogen at 100 kg was applied per hectare as sulphate of ammonia. It was further observed that liming failed to increase the yield of tea even when 200 kg of nitrogen per hectare as sulphate of ammonia was used.

South Bank

In Experiment Nos. AS77 (Betjan *jat*, sandy loam soil) and AS 78 (Betjan *jat*, loamy soil) exactly similar results to those of Experiment No. AN 80 were obtained during 1968.

Sulphate of Ammonia VS Calcium Ammonium Nitrate

In Experiment No. AS 63 (Dhoedam *jat*, loamy soil) in 1968 sulphate of ammonia, calcium ammonium nitrate (once in 3 years--applied in 1966) and NPK mixtures containing sulphate of ammonia, superphosphate and muriate of potash were applied to see whether these are more beneficial than sulphate of ammonia to mature tea in highly acid soils. There was no significant difference in yield between application of calcium ammonium nitrate and application of sulphate of ammonia i. e. no beneficial residual effect of calcium ammonium nitrate was observed. Application of sulphate of ammonia and NPK mixture ($N_{110}\ P_{88\cdot 5}\ K_{33}$) have shown a tendency for higher yield as compared to other treatments.

In another experiment AS 83 (Assam kind of tea-sandy loam) conducted during 1968, the effects of the application of two different doses of lime i. e. at 1 or 2 tonne/ha in conjunction with two different doses of nitrogen i. e. 100 kg or 200 kg/ha, both as sulphate of ammonia and calcium ammonium nitrate were studied. Addition of lime or extra dose of nitrogen over the usual dose of 100 kg N/ha and application of calcium ammonium nitrate have not proved to be beneficial.

Manufacturing and Tasting

Leaf samples from a number of experiments were manufactured in 1968 by the C. T. C. method and the results are given below :

In Experiment No. AS 44 (Betjan *jat*, sandy loam soil) comparing NPK manuring of young tea, tasting of tea samples from different treatments indicated that application of phosphate (P) and potash (K) made no difference to their quality and valuations.

In Experiment No. AS 56 (Khorijan *ja'*, sandy loam soil) on high frequency of application of sulphate of ammonia, it was found that even 247 kg N/ha did not reduce quality, strength and valuation.

In an experiment on pruning cycles AS 12 (Khorijan *jat*, sandy loam soil) there was no significant difference in respect of quality and strength between pruned and deep or medium skiffed teas. In terms of valuation also skiffed teas were no worse than pruned.

In Experiment No. AS 77 (Betjan *jat*, sandy loam soil), where lime was applied at 2 tonnes per hectare in addition to sulphate of ammonia at 100 and 200 kg N per hectare, addition of lime did not improve valuation, quality and strength. Increased levels of nitrogen without lime tended to lower strength but had no effect on quality and valuations.

Miscellaneous

Weedicides

(1) 1 kg of Karmex per hectare when sprayed and mixed with the usual Gramoxone solution (1 : 200) has been found to give good control for three to four months of most weeds commonly found in tea. It should be sprayed on young weeds and it should not be sprayed in areas of tea below three years of age.

(2) The following mixture has been found to control most species of weeds including thatch and Bagracote growing in tea areas. It should not be used in young tea under three years of age.

Gramoxone	...	1.75 litre
Karmex	...	625 gram
SNID-PGN	...	1.75 litre
Water	...	350 litres

This mixture will be adequate to give a blanket spray over one hectare, using a low pressure hand operated sprayer fitted with a flood jet of the fan type.

(3) 2,4-D at the rate of 0.50 kg, 0.75 kg and 1.00 kg active ingredient (i. e. 0.62 kg, 0.94 kg and 1.25 kg of Taficide) per hectare and MCPA at the rate of 0.31 kg, 0.62 kg, and 0.94 kg active ingredient (i.e. 1.25 l, 2.5 l and 3.75 l of Phenoxylene Plus) per hectare were sprayed on to Mikania which was growing profusely over tea bushes. After two weeks, it was observed

that there was some curling of the tender tea shoots in all the treatments, but it was interesting to note that even with as low a dose as 0.50kg 2,4-D active ingredient per hectare, Mikania was completely killed, and after about 15 days the tea started to flush normally.

MCPA completely killed *Mikania* only when it was sprayed at the rate of 0.94 kg active ingredient per hectare. At the lower dosages control was not satisfactory.

Bagracote is fairly resistant to Gramoxone.

Trials were, therefore, conducted in some estates to find out an economical way of controlling this weed and also Mikania. It was found that 0.75 kg of 2, 4-D active ingredient per hectare mixed with a spreading agent such as SNID-PGN or Teepol gave satisfactory control of Bagracote jungle inside tea areas. Unfortunately, it was found that if rain intervened within a few hours of spraying, control was not good. Further trials, however, showed that mixing of Tenac at 1 in 500 parts of the, 2, 4-D spray fluid gave good control of these weeds if there was a dry period of only four hours following application.

Drainage

A number of trials were carried out in estates during 1968 to study erosion in subsidiary drains having various gradients i. e. 1 in 100, 1 in 200, 1 in 300, 1 in 400 and 1 in 500 in different kinds of soils.

It appeared that in loamy or heavy soils, even with drains having near vertical sides, there was neither scouring nor caving in of the sidewalls with as steep a gradient as 1 in 100. Drains of 1 in 100 and 1 in 200 gradients seemed to be self cleaning. In such soils, gradients from 1 in 400 to 1 in 100 can be provided. It is, however, better to confine the gradient to 1 in 300 or in 400.

In sandy soils, the main trouble was caving in of the drain sides rather than the scouring of the drain bed. One trial indicated that in such soils, gradients up to 1 in 400 can be used, provided the side walls are given a correct slope. It is the general experience that in such soils, a minimum slope of $1\frac{1}{2}$ horizontal to 1 vertical is required.

AGRICULTURAL DEPARTMENT

Dr. K. N. Sharma, Senior Agriculturist, died suddenly whilst on duty on the 11th April, 1969 and Mr. S. C. Barua, Second Agriculturist, retired on the 5th July 1969,. At the time of writing this note there is no Officer in charge of the Agricultural Department. In the circumstances it has not been possible to process all the editorial queries on the draft Departmental Report in time to meet the scheduled publication date and so no report will be published for 1968/69.

D. H. L.

SOIL CHEMISTRY DEPARTMENT

Soil survey

The object of the soil survey, method of soil sampling and of chemical and physical analyses are described in Tocklai Occasional Scientific Paper Number 1, which dealt with Jorhat area soils and was published in January, 1968. During the year the soil survey of the following tea districts have been completed :

1. Darjeeling district
2. Cachar
3. Dibrugarh-Doom Dooma district
4. Nazira-Golaghat
5. Nowgong district

Reports on the first two districts have already been published as Tocklai Occasional Scientific Papers, and reports for the remaining three districts are with the Press for publication in the same series.

Soil Rehabilitation

The improvement of the soil aggregate status, between uprooting and replanting by using suitable rehabilitation crops is very important and necessary. Top soil samples from the 15 cm (6 in.) layers were again collected in December, 1968, from the Senior Agriculturist's Soil Rehabilitation Experiment laid out at Borbhetta. Three years fallowing, irrespective of the nature of the cover crops used, has further increased the total soil aggregate percentages in comparison with one and a half year's fallowing. However, the increase due to the additional fallowing for eighteen months, has been found to be in the order of only 7-8 per cent in total soil aggregates.

Studies made on the changes of soil aggregation at various stages of cultivation in the three years rehabilitated plots show the following trends.

(i) *Total* soil aggregate status does not show any change between samples drawn before uprooting of the rehabilitation crops and those drawn one month and three months after uprooting, re-

gardless of the rehabilitation crops being used. But larger aggregates (at or above 1 mm) are, broken down to smaller sizes (less than 1 mm).

(ii) Following three years rehabilitation and then exposure of the soil, deterioration of *total* soil aggregates was not observed upto four months when the samples were taken at monthly intervals. Monthly sampling is continuing to examine the effect of prolonged exposure of the soil on *total* aggregates.

Soil organic matter

The importance of organic matter content in regeneration of soil aggregates has been recognised in our past studies. An exercise was carried out to find out the changes in soil organic matter contents as a result of keeping or removing pruning litter from plots, mulching, and keeping the tea bushes unpruned. Borbhetta field experiments Nos. B. 34.1/7 and B. 106/1 were utilised for this purpose.

Experiment B. 34.1/7, started in 1965, includes three treatments. These are, prunings not removed, prunings removed, and prunings removed but mulch from outside added at the rate of seven tonnes dry organic matter per hectare. Two treatments of the experiment B. 106/1 included in this study, are unpruned tea for the past three years, and tea on a three years prunings cycle of pruning-deep skiffing-medium skiffing. Soils were collected in the last year of the three year cycle.

It has been found that (a) one hectare of 30 cm deep soil (an acre foot) under annually pruned tea lost about 5,000 kg of dry organic matter in three years time due to the removal of prunings; (b) the effect of keeping the bush unpruned for three years is almost equal to the three years of pruning litter additions; (c) addition of mulch from outside at the rate of seven tonnes dry organic matter per hectare, in lieu of pruning litters, has largely arrested the loss of soil organic matter; (d) the organic matter status of the medium skiffed tea in a three year pruning cycle is roughly parallel to the pruned plots from which pruning litters have been removed. It is likely that in the three year pruning cycle plots, organic matter in the way of prunings and skiffings have also been removed by labourers.

Cumulative effects of gramoxone applications

Advantage has been taken of a weedicide trial in young tea laid out at Cinnamara estate by the Chief Advisory Officer for this study. The present soil investigations concern only two treatments of this trial, which are of topical interest. These treatments are normal cheeling, and chemical control using Gramoxone only for the last five years. Chemical and aggre-

gate soil analyses show that practically no difference exists between the long-termed cheeled and Gramoxone treated plots as far as organic matter, available phosphate and potash contents of top soils, and aggregate status of top and sub soils are concerned.

Another investigation was carried out with Margheritta soils, where Gramoxone has been applied at the dilution of 1 part Gramoxone to 200 parts of water as and when necessary to control weeds on two sections of mature tea for the last three years. Soils from a neighbouring cheeled-only section has also been included in the study to serve as a comparison.

It may be mentioned here that Margherita soils are silty clay loams and different from Cinnamara soils which are sandy loam type in texture. Chemical and aggregate analyses of Margherita soils show that significant improvements have taken place in the Gramoxone sections compared to the cheeled sections as far as organic matter, available phosphate and soil structure are concerned.

The differences between Cinnamara and Margherita experiments, as far as cumulative effects of Gramoxone applications on soil properties are concerned, cannot be explained without more critical work. Nevertheless, it can be concluded that at neither site has the cumulative effects of Gramoxone applications caused deleterious effects on the soil properties measured.

Soils of slips areas in Darjeeling

At the eighth meeting of the Darjeeling Area Scientific Committee held on the first November, 1968, shortly after the October disaster, it was decided to investigate the fertility status of the new slip areas as they are before rehabilitation as well as at yearly intervals during the period of rehabilitation which will follow.

Soil samples were collected from five estates, namely, Margaret's Hope, Chong Tong, Nagri Farm, Geille and Bannockburn; each estate in this sampling programme is represented by a minimum of two slip areas to be placed into a rehabilitation programme. Detailed analyses of starting point samples collected at depths 0-15 cm and 15-30 cm have been completed.

It has been observed that on the whole, the top portions of the slips are as chemically fertile as the bottom portions for supporting growth of tea. However, soils at the bottom portions of the slips are less compacted than the top portions, which is probably due to the fact that bottom area soils have yet to settle down again. Further, soils of the bottom portions of the

slips have higher percentages of both total and coarser aggregates than the top portions. With the drift of soils from top to bottom during the storm, there has been also an increase in the percentages of coarser particles like sand, and a concomitant decrease in the percentages of finer particles like silt. In the light of the above observations, it can safely be said that top portions of the slips definitely holds as much promise for replanting as the bottom portions, provided adequate measures are taken for checking further soil erosion and, of course they are properly rehabilitated beforehand.

Detailed analyses of starting point samples, representing 0-30 cm depth, also indicate that soils of the slip areas do not differ very much in textural and most of the chemical properties compared to an average cropped soil in Darjeeling district. The necessity for rehabilitation prior to replantation, however, remains at top priority, particularly for consolidation, and improvements of the physical properties of soils and organic matter content.

Soils from central and east African tea areas

Compared to the best tea soils of North East India, the organic matter content of African tea soils is more than double. As a result African soils are more granular and porous, compared to our soils. Further, detailed analyses of African soils suggest that, on the whole, these are more fertile than our soils. However, a deterioration of soils fertility during early periods of cropping has also been noted with African soils as is our experience in respect of North East Indian tea areas. The deterioration takes place rapidly after felling forest and subsequent planting of tea, but *Eragrostis* mulch at this critical period has helped in alleviating the loss of nutrients and maintaining the physical properties of African soils. The importance of mulching during initial cropping period (when soil remains bare), so often emphasised for our North East Indian soils, gains further support from the results of the analyses of African soils.

Soil Water

Pore space of Tocklai soils at field capacity has been determined using tension table preset at one-third atmosphere. Field capacity pore space, or percentage non-capillary pore space, has been found to be twenty-one as against thirty-two per cent capillary pore space. This information helped to explain the discrepancy noted in water table measurements at Tocklai during monsoon months when the soils are at field capacity. Generally, Tocklai water table records during the monsoon show a five-fold increase in ground water table compared to the rain received during the corresponding period. A five-fold rise in water table is possible at field capacity since field capacity pore space has been estimated to be roughly twenty-one per cent. From these measurements of field capacity pore space and water table movements, it can be concluded that Tocklai soils are free-draining.

Agricultural Meteorology

Computation of evaporation by Penman analysis of meteorological data, as well as direct measurement of evaporation using U. S. class A open pans continued. Meteorological conditions for ten day units have been given for 1968 for all the meteorological sites of Tea Research Association, and a summary of the observations for 1968 is given in the Appendix.

Air Temperature :

The percentage of days when the maximum dry bulb temperature was 30°C or above, has been calculated from long-term data at Tocklai, Silcoorie and Nagrakata. The analyses of temperature data was taken up with a view to supporting the Plant Physiologist's research on shade and leaf temperature problems. The data is presented in the following table.

Table : Percentage number of days with a maximum reaching 30°C or above, for different meteorological sites.

Months	Meteorological station		
	Tocklai (South Bank)	Silcoorie (Cachar)	Nagrakata (Dooars)
January	0.0	0.0	0.0
February	0.0	19.2	3.1
March	40.6	58.4	41.6
April	58.0	81.6	69.7
May	56.1	77.1	65.2
June	79.3	74.4	65.4
July	92.8	86.4	62.1
August	91.9	87.0	67.8
September	87.7	88.3	70.8
October	68.0	75.8	59.7
November	7.0	29.1	2.1
December	0.0	1.1	0.0
Yearly	48.7	56.8	42.5

The general pattern of distribution is the same for all the three stations, but Nagrakata gets a lesser number of days at or above 30°C than the other two sites.

Analysis of Nagri Farm (Darjeeling) data show that even in August, temperatures remains below 29°C. The number of days at or above 25°C

has been found to be 30 per cent in April, 28 per cent in May, 26 per cent in June and July, and 38 per cent in August.

As far as the daily duration of air temperature at or above 30°C is concerned Tocklai data show that out of the total of 92 per cent days in August, half reach 30°C or more for 4-8 hours duration, 26 per cent have a 8-12 hours duration, and 10 per cent stay at 30°C for 12 hours duration. The remaining 10 per cent of the days are of small duration, below four hours. The major growing period of the year suffers from high temperature conditions in North East India with the exception of the Darjeeling district.

Temperature and humidity under shade :

Piche evaporimeters placed under bamboo screen, shade tree and open have indicated that evaporation under bamboo screen is least throughout the dry period (see p. 48, 1967,68 Annual Report,. During the dry period of 1968/69, air temperatures and relative humidity have also been measured under different environmental conditions imposed by bamboo screens, shade trees and in the open. For this purpose, thermo-hygrographs were placed inside stevenson screens installed at a height of 120 cm (4 ft.) above the ground level.

It was found that under shade trees higher temperatures prevailed during January to April, 1969, generally between 1600 and 0500 hours I. S. T. compared to either the open or under the bamboo screens. Temperatures in the open and under bamboo screen remain almost indentical during these four months.

Records, show that under both shade trees and bamboo screens a higher level of humidity is maintained, between 0600 and 2000 hours I. S. T. during January to April than in the open. The differences in humidity between shade and the open, increase from morning till afternoon; the maximum differences being recorded at 1400 hours. The maximum and minimum peaks of humidity correspond to 0600 and 1300 hours I. S. T. respectively, which are the standard timings for recording meteorological observations in tea areas.

Rainfall measurement :

It is often assumed that a standard raingauge, however placed, will measure precisely the quantity of rain falling. This assumption may not be at all valid, as a number of investigators in other countries have shown.

Rainfall catch as affected by the height of a gauge was studied by placing gauges at 0, 30, 60, 120 and 180 cm above soil level. The experiment was carried out in the Toeklai meteorological site. The standard raingauge

is mounted on a cement concrete base built at ground level and the gauge mouth is 30 cm above ground level. In order to safeguard against likelihood of splash into the ground level gauge, the latter was surrounded by an anti-splash grid.

During the first four months of the experiment, in the dry period of January to April, 1969, the ground level gauge caught about three per cent more rain than the standard gauge 2.4 m (8 ft.) away. Also, the gauges at 60 and 180 cm heights showed less catch than the standard gauge. The catch of 120 cm gauge appears to be erratic. The comparison between gauges at ground level and at the standard height of 30 cm (1 ft.) is likely to be of great importance in hydrological studies.

Rainfall intensity :

Splash run-off from bare soil is closely associated with rainfall intensity. Rainfall data for 1966 of all the four meteorological stations (Tocklai, Silcoorie, Nagrakata and Nagri Farm) were analysed monthwise into two arbitrary categories, erodable or high intensity rain and non- erodable or low intensity rain. Rainfall of 1.5 inch or above per hour for a period of 5 minutes or more duration is considered as erodable rain, and rainfall of less than 1.5 inch per hour is taken as non-erodable rain.

The analyses shows that the percentage erodable rain is the highest at Nagrakata and lowesst at Nagri Farm and decreases in the order :
Nagrakata (Dooars), Tocklai (Assam), Silcoorie (Cachar), Nagri Farm (Darjeeling). Nearly 80 per cent of the erodable rain fell during May to August in all the four sites and during this period roughly 70 per cent of the total yearly precipitation fell.

Rainfall analyses :

Rainfall analyses has been carried out utilising standard raingauge data recorded at Tocklai from 1921 to 1960. The analyses has been carried out by grouping every five years data into eight different categories of daily rain, namely, .01-.09 in., .10- .39 in., .40-.79 in., .80-1.19 in., 1.20-1.59 in., 1.60-1.99 in., 2.00-3.99 in., and 4.00 in. and above. The object is to find out monthly distribution of rainfall according to category of daily rain. The same study has also been extended for Cachar and Dooars, utilising thirty years estate data recorded at Silcoorie and Bhogotpore respectively.

For all the four meteorological sites, quantities of highest and lowest rainfall in each month and their duration as well as probable rainfall for 48, 72 and 96 hours have been worked out from long-term automatic syphon raingauge data.

Rainy days :

An attempt was made to find a general relationship between number of rainy days and total rainfall using long-term data, namely 50 years data at Tocklai, 10 years data at Silcoorie, and 8 years data at Nagrakata and Nagri Farm. A rainy day is defined as one on which at least one hundredth of an inch of rain falls. In all the four sites, strong positive correlation has been found. The relationship for Tocklai has been found to be linear, whereas for other stations the relationships have been found to be exponential.

Research and advisory analyses

Roughly 18,000 soil analyses have been made during the year. The break-up is as follows :

(i) Research : For soil survey alone 7,800 estimations have been carried out.

(ii) Advisory : (a) pH, nitrogen and organic matter : 8,000 estimations.
(b) Available phosphate and potash : 100 estimations.
(c) Aggregate analysis : 2,000 estimations.

The demand for aggregate analysis continued with a large increase over the previous year. Besides, leaf, manure and drainage water have also been analysed occasionally as demanded by *ad hoc* investigations.

BOTANY DEPARTMENT

RESEARCH & EXPERIMENT

Plant improvement

Production of biclonal seed

The announcement for the release of the first bielonal seed stock (No. 378, Nandadevi & suitable for Darjeeling) produced at Tocklai was made last year (Ann. Rep. 1967/68, p. 50-52). Following this announcement parts of two seed baris of this Stock, one at Tocklai and the other at Nagrakata, were planted up during the year. Each of these baris will be extended to cover two hectares.

Screening of all bielonal progenies raised from hand-pollinated seeds was completed during the year. Six of these progenies were found promising in yield and cup characters and the parental clones of these progenies were propagated vegetatively to plant small seed baris for the production of seeds under conditions of natural pollination. In due course progenies of these six crosses will be tried out at Tocklai and commercial estates.

The procedure for selecting parental clones on the performance of their hand-pollinated progenies is time consuming; the time taken from pollination to the selection of clones being never less than seven years. An attempt has been made to do away with this lengthy procedure by selecting the parental clones on the basis of their individual performance and compatibility in crosses. Two pairs of clones have already been selected on these criteria for planting small seed baris. The success of this method will be known only after the progenies of these baris are tried out in due course for yield and cup characters.

Cytological investigation

Large number of cytological observations have so far failed to reveal any difference in the chromosome structures of different kinds of tea. The chromosomes of a few species of plants related to tea were also examined to see if these species make any contribution to the genetic make up of the tea plant, but no definite conclusion is possible at this early stage.

It was stated (Ann. Rep. 1967/68, p. 53) that while the normal functional cell of a tea plant contains two sets of 15 chromosomes each, some plants were found with three sets (triploid = 15) and others with four sets (tetraploid = 60) of chromosomes. A plant with six sets of chromosomes (hexaploid = 90) and some peculiar plants with incomplete sets, having 32, 38, 40, 42 and 50 chromosomes were also discovered during the year.

Induction of mutation and polyploidy

Another trial on the treatment of tea seeds with mutagenic rays was carried out during the year, through the courtesy of the Indian Agricultural Research Institute, New Delhi, to investigate the possible causes of non-germination of the irradiated seeds. In this trial arrangement was made for quick transport of seeds to and from New Delhi and irradiation at low doses. Despite these precautions the treated seeds failed to germinate, while seeds packed in the same way and stored in the laboratory at Tocklai for the same length of time germinated satisfactorily. It appears that desiccation of the seeds during transit in spite of careful packing in polythene tubes is responsible for their failure to germinate.

A recently reported chemical mutagen, ethyl methyl sulphonate, has also been tried on tea seeds for inducing mutation. Its effect will be known only after the seeds germinate.

As with the previous trials, induction of polyploidy by treatment of tea plants with colchicine has met with little success. The series of unsuccessful experiments with this chemical suggests that the tea plant, like some other woody plants, is not responsive to colchicine.

Release of Vegetative clones

Two more clones, TV 16 and TV 17, were released during the year.

TV 16 is a STANDARD clone similar to clone 19 29 13 (TV 1) in cup-characters and yield in the trial areas at Borbhetta. It has a darker flush, bigger leaves and a higher yield potential than 19 29 13; nevertheless its frame is as compact as 19 29 13. The clone is likely to be more suited to Cut-leaf systems of manufacture.

TV 17 is another STANDARD clone similar in many respects to clones TV 1, TV 14 and TV 16. It has darker and bigger leaves and a frame which is more spreading than TV 1. In a trial at Borbhetta, the clone yielded more and received consistently better valuations than the other clones including TV 1. The clone makes good tea both by the Orthodox and the Cut-leaf methods of manufacture.

Clonal criteria

The necessity of objective criteria for recognising and differentiating clones and for assessing liquor characters was explained in last year's Annual Report (p. 53). In search of such diagnostic criteria, 46 morphological and anatomical characters were measured on 10 clones known for their yields and cup-characters. It was observed that the range of variation of certain characters e. g. thickness of cuticle, number of pallisade

layers, thickness of leaf lamina, number of stomata per unit area etc. was very narrow, while other characters e.g. angle between stem and leaf, angle of branches, shape of leaf apex and base etc. had varied over a wide range between the clones. The year's observation, therefore, helped in isolating these latter group of about 30 characters which will now be determined on a wide array of 70 clones covering the entire range of cultivated tea and the data will be analysed in a computer.

One interesting observation of immediate practical value was made in the course of this study. The yearly average dry matter content of shoots plucked in the same way from the different clones under observation varied from 22.3 to 25.8 per cent, which means that the out-turn of made tea from the same quantity of fresh leaf plucked from two different clones may vary by as much as 15 per cent. This factor, therefore, deserves serious attention in the selection of vegetative clones.

Light shade decreased the dry matter content of the plucked shoots of a clone by 3 to 4 per cent, which agrees well with the results published in the Annual Report for 1957 (pp. 37-39) for a population of seed-grown tea. As expected , the dry matter content of plucked shoots decreased during the rainy months and increased during the dry early and late parts of the plucking seasons.

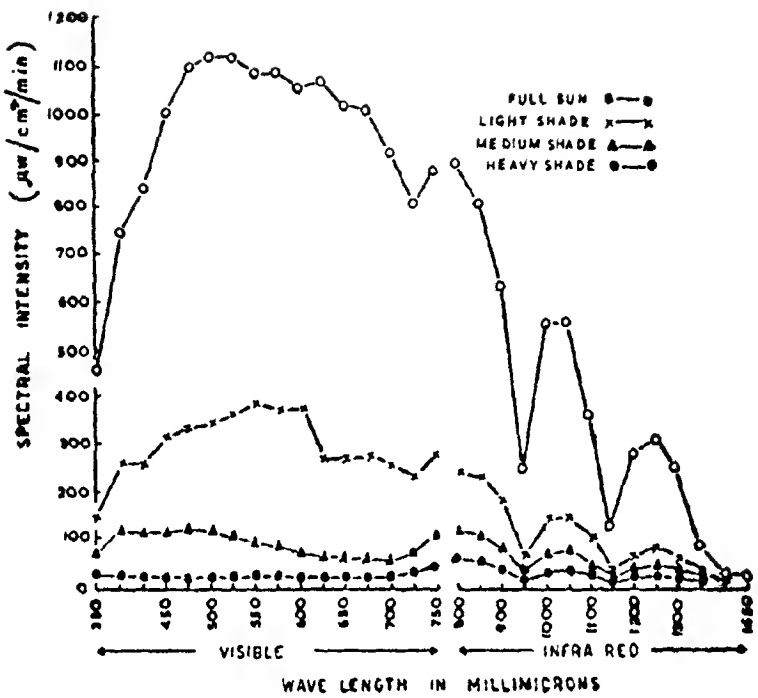
The results reported last year (pp. 54-55) that Tea Tasters' assessment of a sample of tea is based on the value and proportion of each of the shoot components (e. g. bud, first leaf, stem etc.) in the sample was confirmed with clonal leaf. Variation of shoot components between clones is under investigation.

Plant Physiology

Spectral composition of light under shade trees

In continuation of the physiological studies reported in 1968, the spectral analysis of light before and after passing through canopies of *Albizzia* trees was measured using a Spectroradiometer. Both the visible and infra red parts of the spectrum were measured and the *Albizzia* canopy was manipulated to emulate light, medium and heavy shade. Fig. 1 shows a typical set of readings taken in full sunlight.

FIG 1



Intensity of sun light at different wavelengths on a bright summer day when measured in the open 'O.....O', under light *Albizzia* shade 'X.....X', under medium shade '△ ..... △' and under heavy shade '⊙.....⊙'. The horizontal axis indicates the quality of light and the vertical axis shows the quantity of light energy recorded at different wavelengths in full sun and under the three shade densities. Light intensity at different wavelengths is expressed in milliwatts per square centimetre per minute.

Even under the light shade which produced a very even, dappled effect due to the pattern of leaflet shadows and small sunflecks, there is a marked absorption of those wavebands (400-450 mμ and 600 - 700 mμ) associated with action peaks of photosynthesis, showing that a considerable amount of useful radiation had been removed from the solar spectrum before it reached the tea canopy. There is however a large amount of harmful infra red radiation absorbed by a shade canopy of this nature, in this case over 70% of the total present in full sunlight, and it is likely that this reduction in infra red radiation, and hence cooler tea leaves, more than compensates for the reduction of potentially useful visible wavebands under climatic conditions of high ambient temperatures and low windspeeds.

As can be seen from Fig. 1 more radiation is absorbed at all wave lengths as the shade becomes more dense. Medium shade, as used in these experiments, approximated to a fully foliated high canopy of *Albizzia odoratissima* trees.

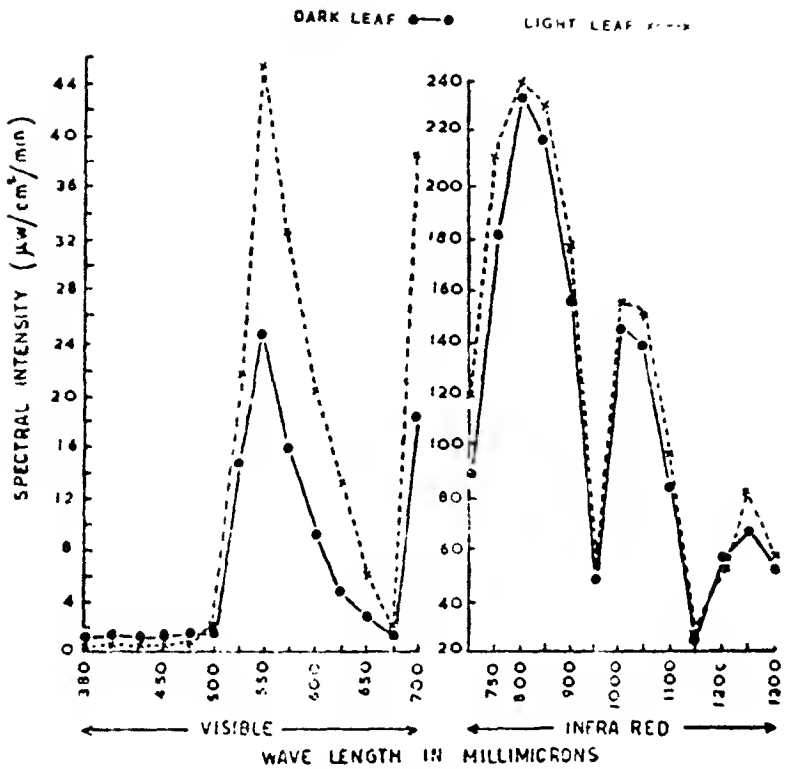
It is of interest to note that as the shade density increases, proportionately more of the visible light is lost and proportionately more of the infra red is transmitted although, as mentioned above, the total amounts of both together decrease.

The conclusion to be drawn from these results is that unless a shade tree allows undiluted sunlight in the form of sunflecks to reach the tea canopy, it may be considered too dense for the optimal growth of tea plants. A simple field method of determining the presence of sunflecks is to hold a large sheet of clean white paper on the surface of a tea bush directly under the shadow cast by a shade tree at noon on a clear day. If no sunflecks are present, the branches of the tree may be lopped until sunflecks appear. This method will increase light intensity without changing canopy width and is infinitely more preferable than to removing alternate trees which only results in creating overshaded and unshaded areas.

Light transmission through tea leaves

The amount and quality of light passing through a single tea leaf was measured, both for dark and light leaf varieties, choosing leaves of equal thickness. Fig. 2 shows the light transmitted by the two types of leaves in the visible and infra red wavebands. The values in the infra red are so high that a separate ordinate is used in Fig. 2 for values from 725 mμ to 1300 mμ.

FIG. 2



Quality and quantity of light passing through single leaves of dark and light leaf tea plants. The horizontal axis indicates the quality and the vertical axis the quantity of transmitted light. Quantity of light energy is expressed in milliwatts per square centimetre per minute.

Comparison of Fig. 2 with the 'full sun' curve of Fig. 1 will show that only a very small fraction of the *visible radiation* (about 2 per cent) passed through the tea leaves, while the fraction of infra red radiation transmitted by the leaves was much higher, nearly half of that in full sun.

The selective absorption of visible and infra red radiations by tea leaves should result in a change in the quality of light inside the canopy of a tea bush compared to that on the surface—the proportion of infra red radiation inside the bush canopy should be much higher than on the bush surface. This was confirmed by using a remote probe connected to the Spectroradiometer. Fig. 3 which is drawn in another context, serves as an example showing the relatively higher proportion of infra red radiation inside a bush canopy than in the solar radiation incident on its surface (See Fig. 1).

It is clear therefore that to obtain meaningful readings of photosynthetically useful light (in the visible waveband) inside dense canopies, receptor cells must have sharply defined sensitivities and cut offs, if the high values of infra red and far red radiations are to be excluded.

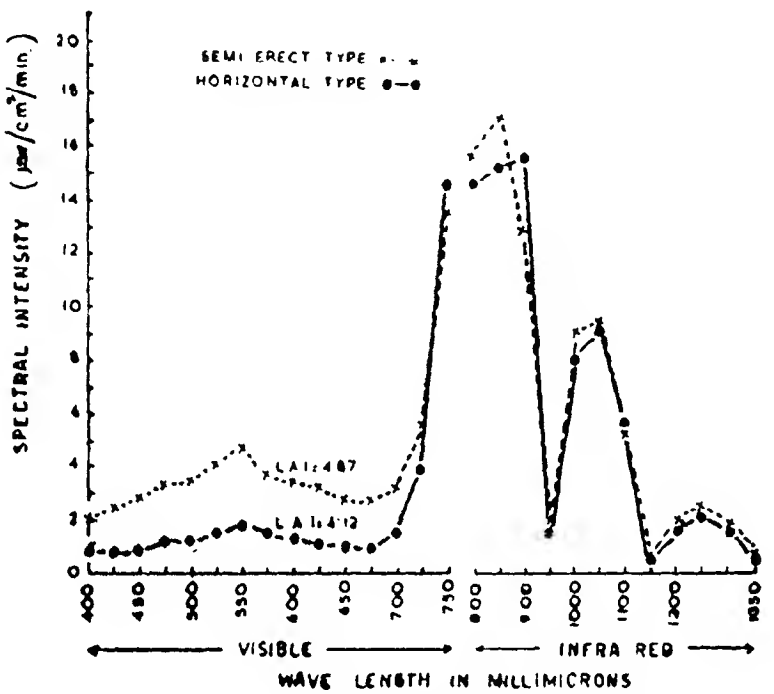
The lesser amount of transmission in the visible range between 525 mμ and 650 mμ by the dark leaf of Fig. 2 suggests that chlorophyll may be present in greater amounts in this than in the light leaf, as this region approximates to the absorption bands for chlorophylls a and b. Chlorophyll determinations for each leaf type are given in Table I, which indicate that the difference in transmission in this region is, in fact, due to the difference in the chlorophyll content.

Table 1. Leaf area, fresh weight, chlorophyll content and their ratios for dark and light tea leaves used in spectral transmission studies

	Light leaves		Dark leaves	
	1	2	1	2
Leaf Area (cm^2)	138. 5	90. 0	95. 8	66. 8
Fresh weight (gm)	2. 36	1. 75	1. 79	1. 35
Chlorophyll a (mg)	2. 75	2. 06	4. 35	3. 92
Chlorophyll b (mg)	1. 06	0. 81	2. 23	1. 63
Total Chlorophyll (mg)	3. 81	2. 87	6. 58	5. 55
Total Chlorophyll (mg)	3. 81	2. 87	6. 58	5. 55
$\frac{\text{Chlorophyll a}}{\text{Chlorophyll b}}$	2.594	2.543	1.951	2.405
Total Chlorophyll in mg per cm^2 of leaf	0.028	0.032	0.069	0.083
Total Chlorophyll in mg per gm fresh wt. of leaf	1.614	1.640	3.672	4.116

The quality and quantity of light reaching the lowest leaves in semi-erect and horizontal leaf type bushes was also determined and results are shown in Fig. 3.

FIG. 3



The quantities and qualities of light reaching the lowest leaves of the top hampers of horizontal and semi-erect leaf type bushes. The quantities of light at different wave-lengths are expressed in milliwatts per square centimetre per minute.

The total amount of leaf surface on each bush was measured and shown as Leaf Area Index (L. A. I.) against the spectral curves in the figure. The quantities of light energy reaching the lowest leaves were extremely small in both leaf types. However, in spite of a greater leaf area in the semi-erect type, the lowest leaves received relatively more light than the horizontal type, and although the values of the infra red part of the spectrum were almost equal, there was twice as much visible, photosynthetically useful radiation (mainly diffuse light) in the semi-erect canopy. From previous studies on the geometry of the different foliage systems this result is not unexpected but provides powerful support to the idea that leaf angle plays more important role in light penetration than leaf area. The optimal L. A. I. for different types of bushes will be investigated in the near future.

Shade × nutrient × clone trial

The shade × nutrient × clone trial at Tocklai, consisting of 7 erect, 12 intermediate and 6 flat leaf clones, was completed this year and the area is being used for other experiments. The data collected from this experiment during the last nine years are being re-examined in the light of our recent findings on leaf pose, light penetration and productivity of tea clones.

Spacing of clones and *jats*

A simple approach to the spacing of clones, mentioned in last year's Annual Report (p. 57), was tried out by determining the pattern of distribution of plucking points on the surface of annually pruned tea bushes at the close of the plucking season. Two 11 year old clones of the Jorehaut Tea Company Ltd., planted at Cinnamara T. E., and one seed population of the same age planted at Borbhetta were used for observation and we are obliged to the Jorehaut Tea Company Ltd. for making their clonal plots available to us. The clones and the seed *jat* were planted at five different spacings in contiguous plots. The closest spacing available for our observation was 61 cm within rows and 122 cm between rows.

At the time of observation the plucking table of these annually pruned bushes was approximately 90 cm above the ground surface. In theory, the bushes should have covered the ground completely within 5 or 6 years from the time of planting.

Additional observations were made on four clones at Borbhetta, but the plots with different spacings being non-contiguous and of different age, no valid comparison could be drawn between these clones and their spacings.

For counting plucking points, a light grid divided into squares of 10 cm sides was placed on top of a bush, the centre of the grid coinciding as nearly as possible with the bush centre and one of its axes remaining parallel and the other at right angle to the row of bushes. The number of plucking points counted in each square of the grid was recorded in the corresponding cell of a sheet of paper ruled in squares, using a separate sheet of ruled paper for every bush. Thus a complete record of the shape, size and plucking point distribution of each bush was miantained separately . Plucking point count was made in December on 10 to 12 representative bushes at each spacing taken from the inner rows of a plot.

Within the limits of our observations the following facts have emerged from a preliminary examination of the data :

(a) Closeness of planting did not increase the average plucking point density per bush, i. e. the average number of plucking points per unit area of bush surface.

(b) The average density of plucking points per bush was not affected by square or rectangular pattern of planting.

(c) The plucking point density varied between clones.

(d) There was hardly any variation in plucking point density within a radious of 30 cm (1') from the bush centre, regardless of the spacing and arrangement of bushes. Beyond 30 cm, the plucking point density gradually declined, reaching a minimum at the periphery of the bush.

(e) Better ground coverage was provided by bushes planted at closer spacings.

The results under (a), (b), (c, and (e) are illustrated by Table 2.

It follows from (d) that planting closer than 60 cm within the row is unlikely to make any difference in yield and this was true for the two clones and the *jat*, all of which were bushes with wide, spreading frames. A planting distance of 60 cm between bushes in the row may therefore be regarded as the optimum for spreading bushes. We had no opportunity for examining comparable clones and *jats* with narrow, compact frames; hence it is not possible from our observation to suggest the optimum within-row planting distance for such clones and *jats*. The few observations made on the four Tocklai clones at Borbhetta, however, tend to suggest that narrow-framed bushes may require still closer spacings for maximum production of shoots.

Table 2. The average plucking point density and ground area covered at different spacings

Source	Spacing		No. of bushes per hectare	Plucking point density	Percent ground area covered
	Cm	Feet			
J. T. C. L. Clone No. 1	152×61	5×2	10,764	4.8	86
	122×91	4×3	8,970	8.0	82
	152×76	5×2	8,611	6.6	78
	152×91	5×3	7,176	7.5	75
	122×122	4×4	6,727	5.6	80
			Mean	6.5	80.2
J. T. C. L. Clone No. 2	152×61	5×2	10,764	8.4	89
	122×91	4×3	8,970	9.5	87
	152×76	5×2	8,611	8.0	84
	152×91	5×3	7,176	8.2	74
	122×122	4×4	6,727	8.4	84
			Mean	8.5	83.6
Borbhetta *Jat*	122×61	4×2	13,455	8.3	100
	152×61	5×2	10,764	8.7	100
	152×76	5×2	8,611	8.8	86
	122×122	4×4	6,727	7.4	87
	152×98	5×3.2	6,706	8.8	86
			Mean	8.4	91.8

If we ignore for the time being practical considerations e. g. free movement of pluckers, it can be argued theoretically that the optimum space allotment within and between rows should be the same i. e. 60 cm for spreading bushes, to obtain the highest density of plucking points over the entire planted area. While this may be so in theory, it remains to be seen by actual observation whether such close planting can have adverse effect on growth and longevity of the bushes. The closest inter-row spacing available for our observation being 122 cm. examination of tea planted much closer will therefore be necessary to arrive at a definite conclusion regarding the optimum planting distance between rows. In the absence of this information, one can only follow the current practice of leaving 120 cm between rows, to facilitate the movement of workers.

Consideration of the frame geometry of a plucked tea bush shows that the minimum space allotted to each bush for the maximum utilisation of ground area will vary with the height of the bush frame; the higher the frame, the less will be the number of bushes required to cover the ground completely. This factor cannot be ignored in any consideration on spacing. The 60 cm spacing indicated by our measurements to be the theoretical optimum for bushes within a row may not hold good for bushes having higher or lower plucking tables.

The space covered by bushes after a certain lapse of time from planting depends on their intrinsic vigour and a favourable environment and also management methods. The seed *jat* provided complete ground cover at 152 cm × 61 cm spacing, while the clones of the same age failed to do so at the same spacing (Table 2) although they were intrinsically more vigorous. This is a clear reflection of the growing conditions; closeness of planting failed to overcome the limitations imposed by poor growing conditions.

Data in Table 2 lead to the conclusion that healthy bushes at whatever conventional distances they are planted will be more rewarding than closely planted stands of non-vigorous tea, except perhaps in the very early years following planting.

Seasonal dormancy in tea

In an earlier report (Ann. Rep. 1966, p. 38) the cause of winter dormancy of tea at high latitudes was suspected to be short day length(conversely, long nightlength). This hypothesis was verified experimentally during the winter of 1968/69.

Pruned and unpruned bushes were exposed to 13 hour days from November 15 to March 31 by providing supplementary artificial illumination

during the morning and evening hours. The illumination intensity from incandescent lights in the visible part of the spectrum (380 to 780 mμ) was less than one per cent of the visible solar radiation on a bright summer day, and was considered too weak to make any difference to dry matter production. One half of the experimental area was irrigated with 5 cm water every month from November to March and the other half had no irrigation.

Illumination markedly increased the crop harvested from the irrigated, unpruned bushes between end November and early March and the crop from both irrigated and unirrigated bushes harvested in April and May. It also hastened bud-break on pruned bushes. The number of flowers on the unpruned bushes was also drastically reduced by illumination. These results, therefore, lend support to the hypothesis that winter dormancy in N. E. India is the effect of short days.

Many effects of day length (more correctly night length) have been traced to changes in the balance of growth regulating substances in the plant. Our investigation was therefore carried a step further by injecting into dormant tea plants two chemicals, gibberellic acid (GA) and kinetin (K), both of which are known to affect plant metabolism. Injection was given on December 30 to single-stemmed, 15 months old, dormant plants of two clones using two concentrations of the chemicals, at 10 and 10 parts per million.

The plants injected with GA at both concentrations promptly made a new flush of growth within six weeks when untreated plants and plants injected with K and distilled water showed no sign of growth. By the first week of May, the GA treated plants completed two flushes of growth while most plants in the other treatments and the untreated controls remained dormant after completing one flush.

By itself K had a slight depressing effect on vegetative growth and it strongly inhibited the stimulatory effect of GA in a combined GA + K treatment.

The conclusion drawn is that winter dormancy of tea at high lattitudes cannot be broken by conventional, commercial treatments and any attempt to do so will result in failure. The results, however, open up the possibility of breaking or preventing dormancy by artificial illumination or by treatment of bushes with gibberellic acid.

Miscellaneous

Internal reorganisation of the Botany laboratory was carried out during the year. Altogether 11 rooms including a dark room for photography, were constructed inside the laboratory for offices, store, herbarium and equipment, still leaving enough working space and sitting accommodation for the staff. The work of the laboratory suffered dislocation for about six months while the construction was in progress.

The annexe to the main laboratory, used in the past as an office, is being partitioned into three rooms, one of which will be a laboratory for radio-tracer work, one will be handed over to the Biochemistry Department for housing their delicate instruments and the third will be a control environment growth room. Installation of equipment for controlling humidity and temperature in these rooms, particularly in the growth room, is expected to begin by the middle of 1969.

To concentrate all work on tea breeding in one area, 4.5 hectares of land under shrub jungle and situated within 500 metres of Tocklai were purchased during the year. The area was fenced, ploughed, levelled and drained, in preparation for planting grasses and green crops after the spring rains.

ADVISORY

Touring : Dr. D. N. Barua visited four estates in Assam, Mr. W. Hadfield visited three estates in Assam, and Murmuria T. E. on a number of occasions in connection with the Shade - Nutrient experiment and Mr H. P. Bezbaruah visited five estates in Upper Assam, six estates in Cachar and fifteen estates in the Dooars and Darjeeling. Dr. D. N. Barua visited Darjeeling along with the Director after the North Bengal floods.

Study leave : Mr. W. Hadfield spent nine weeks at Cambridge University, U. K., making further study on the shade problem in tea.

Meeting : Dr. D. N. Barua attended one meeting of the Standing Committee of the I. C. A. R. in New Delhi in August. Mr. H. P. Bezbaruah attended a Symposium in March on "Genetic Improvement of Economic Plants in India" organised by the I. A. R. I. in New Delhi and presented a paper on "Genetic Improvement of tea in North East India- Its problems and possibilities".

ENTOMOLOGY DEPARTMENT

Tea mites

Scarlet mite (*Brevipalpus phoenicis* Geijskes) : Evidence on hand does not suggest a clear cut preference of scarlet mite for either China or Assam varieties of bushes. China *jats* growing in Assam had more mites than Assam *jats*. In the Dooars, light leaf and dark leaf Assam *jats* were equally prone to the mite, but in Darjeeling, China hybrids were more susceptible than the Assam light leaf *jats* during October to March.

Skiffed tea in Assam had higher scarlet mite infestations all the year round than pruned tea. In the Dooars however that situation existed only in the first half of the year : following the July rainfall there, the incidence of mite became the same on both pruned and skiffed tea. Skiffed and pruned teas in Darjeeling were equally susceptible from April to August but not during October to March when the former had more mites.

By and large, mites were less in poorly shaded tea than in unshaded tea, and less still in well shaded tea of the same age and variety. But these differences according to shade were noticeable in Darjeeling and the Dooars only during October to March and April to September respectively.

Scarlet mite populations on mature China hybrid bushes in Darjeeling at 1,350 and 1,200 metres were not significantly different, neither were they on eastern, western and southern slopes at any particular elevation.

Red spider (*Oligonychus coffeae* (Nietner) : During October to February no significant differences were found in the incidence of red spider on southern and northern slopes in pruned, skiffed and untouched teas in Cachar. But from April to September, all types of tea on northern slopes had more mites than those on southern slopes.

Application of DDT 50% W. P. (0.1%) increased the fecundity of the mites under laboratory conditions, but not Thiodan 35 E. C. (0.07%) and Endrin 20 E. C. (0.02%). These experiments carried out in the absence of natural predators of red spiders, suggest that DDT by itself can activate mites into higher egg production regardless of any deleterious effect it might have on predators under field conditions.

Murmuria project : Comparative ecological studies on the mite complex of tea are in progress. Species wise weekly records of mite populations are being maintained for all plots with different shades and manurial treatments.

Pink mites (*Acaphylla theae* Watt (Keifer) were most numerous in the upper frame of the bushes, but not red spider, scarlet and purple mites.

Tea Aphid

Two peaks, one each in February and October, were noticeable in the annual population cycle of the aphid (*Toxoptera aurantii* Boyer) on 15 year old tea. Although lower than the February peak, the second peak in October had a high proportion of alates in it. These winged forms swarmed out at dusk during November to January and were recorded flying at a height of 2 metres.

The search for natural predators of aphids was continued and the following are the new records :

Syrphidae : Diptera

1. *Paragus yerburiensis* Stuck.
2. *P. indicus* Brun.
3. *Asarcina aegrota* Fab.
4. *Xanthogramma scutellare* Fab.

Coccinellidae : Coleoptera

5. *Menochilus sexmaculatus* (F.)
6. *Coccinella repanda* Thunb.
7. *Leis dimidiata* (F.) var *quindecimmaculata* Hope.
8. *Coccinella septempunctata* L. var *divaricata* Ol.
9. *Pseudaspidimerus circumflexus* (Mots)
10. *Epilachna* sp.

An earlier list was given in the Annual Report for 1966.

Menochilus sexmaculatus was a common predator and its life cycle was worked out under laboratory conditions. The incubation, larval and pupal periods were approximately 7, 8 and 4 days respectively. An adult beetle in its life time of 133 days consumed 7,640 aphids, an average of 57 per day. The maximum actually consumed in one day was 140. Because of its short life cycle and high feeding rate *M. sexmaculatus* is an effective predator in the field.

Seasonal distribution of the predators in the field synchronized fairly well with those of the aphids, although all the predatory species mentioned above were not simultaneously available at any one time of the year. Predator populations were high during January to February and again during October to November thereby presumably causing natural reduction of aphid populations in the subsequent months.

Applications of Thiodan 35 E. C. (0.16%), Rogor 40 E. C. (0.04%) and Metasystox 25 E. C. (0.02%) reduced predator populations both in the field and in the laboratory. Each of these insecticides at the same time gave 75-85% reduction in aphid populations in the field.

Tea Thrips

The population of the Assam thrips (*Scirtothrips dorsallis* Hood) was on the increase from March when new shoots and buds were appearing on tea. From August, the populations declined.

Bunch caterpillar

Preliminary studies showed that when covered with mulch during November and December, the majority of the pupae of *Andraca bipunctata* Wlk. failed to develop. This resulted in a lesser emergence of the moths and subsequent damage causing caterpillars. Mulching inhibited pupal development possibly through the reduction of soil temperature and retention of moisture.

Pests of shade trees

Shade trees canker: Larvae of *Agrilus beesoni* Obenberger together with other micro-organisms cause canker on *Albizzia odoratissima*, *A. lebbeck*, *A. chinensis* and *A lucida* both in the nursery and after they are transplanted to the field. In the field, trunks and side branches are equally prone to cankers and cankers are common between a height of 1 to 3 metres.

The life cycle of the beetle was studied in the laboratory by inoculating excised branches of *Albizzia odoratissima* with first instar grubs of *Agrilus beesoni*. The experiment was started in August and by September the grubs had started tunnelling beneath the bark and reached the second instar stage. At this stage , gummy exudations started coming out of the tunnels. In November the tunnels were extensive and individual ones reached a length of 34 cm. Exudation continued. The grubs reached the fourth instar stage and then started pupating, with adult beetles emerging in December. Portions of the branch surface, with tunnels inside, became cankerous particularly when exposed to air.

Unidentified hymenopterous and nematode parasites were found within the grubs and the adults of *Agrilus beesoni*. Detailed studies of these parasites are in hand with an eye on the potential of using them for biological control.

Shade tree defoliator : Caterpillars of the Lycaenid butterfly (*Surendra quercatorum* Moore) were noticed damaging growing shoots of *Albizzia odoratissima* in the nursery. The butterfly laid eggs on the leaves and the caterpillars on emergence started feeding on the foliage. The larval period lasted 20 days and pupal stage 8 days.

Nematodes

Standardization of technique : A new and simple method for extracting nematodes from soil was tried. The equipment was a nylon dish filter (15 cm diameter) placed in the centre of an enamel extraction dish (height 5 cm : diameter 25 cm) containing water. Soil, emulsified with water, was evenly sprayed out on the nylon dish. The nematodes emerged from the soil suspension and passed through the nylon sieve into the water of the outer extraction dish. Samples of water from the outer dish were examined every two hours for nematodes. Using this technique 80% of nematodes were recovered within 10 hours from samples with known nematode densities, against 24 hours for the same level of extraction by the standard Baermann technique. Experiments are in progress to refine this technique particularly towards obtaining cleaner suspensions.

Multiplication during storage : Replicated experiments were conducted in the laboratory, storing equal amounts of soil with known nematode densities in wooden boxes and polythene bags. Samples drawn at 15 day intervals for 150 days showed that in wooden boxes, populations steadily declined from the 30th day onwards. But in polythene bags populations stayed almost constant upto the 45th day after which a slight increase was noticeable. Conditions of the soil during storage might have some effect on nematode multiplication, because the soil went dry in the wooden boxes but remained moist in the polythene bags. This study emphasizes the need for quick analysis of soil samples and the rapid extraction technique mentioned above could be useful.

Clonal susceptibility : Several groups of nematodes were found in the rhizospheres of eight Tocklai release clones when they were two to three years old. Important and dominant, were *Rotylenchus*, *Hoplolaimus*, *Pratylenchus*, *Paratylenchus* and *Tylenchorhynchus*. Small numbers of *Criconemoides*, *Tylenchids* and *Xiphinema* were also present. Curiously, *Meloidogyne* (root knots) common in seedlings in the nursery, was found only in clones 14/9, 1/71 and 20/7 but not so far in the other clones. Pathogenic studies with *Pratylenchus* and *Meloidogyne* are in progress.

Incidence on rehabilitation crops : Ecto and endoparasitic species were isolated from the soil samples collected from around the roots of the

29 species of newly introduced rehabilitation crops. *Pratylenchus* was associated with all species of grasses, but their numbers were not high enough to be of immediate consequence. Grasses had also a low incidence of *Meloidogyne*. All crops were equally susceptible to *Tylenchids* though their pathogenic effects were not clear. Populations of *Rotylenchus*, *Criconemoides* and *Xiphinema* were high only during the rains.

Conventional green crops had high infestations of *Meloidogyne* and the order of incidence on some major crops was : *Crotalaria anagyroides* < *Priotropis cytisoides* < *Tephrosia candida* < *Desmodium gyroides*.

Effects of mulch and manure : Plots treated with organic mulch had a low incidence of *Paratylenchus*, *Rotylenchus* and *Tylenchids* and high incidence of predatory nematodes in comparing with soils from no mulch plots. Rapid feeding by the predacious nematodes possibly kept the parasitic groups under control. In the absence of these predators, parasitic species in non-mulched plots multiplied rapidly.

The nematode fauna of virgin plots consists mostly of non-parasitic species. But after an application of YTC manure mixture followed by the planting of shade trees (*Indigofera teysmanni*), parasitic groups like *Meloidogyne* began to appear about a year afterwards.

Soil samples from these areas will be examined further to find out possible repercussions of major soil treatments on the degree and nature of nematode infestations.

Tea soil Fauna

Eighteen species of insects, eight mite species, two diplopod species and a species of isopod are but a few of the organisms forming complex fauna of tea soil. The number of entomobryid collembolas and uropodid mites were high during July to September. Diplopods were trapped on the surface soil during April and their numbers increased gradually during June to July. Work has begun to study the effects of chlorinated hydrocarbon and organophosphorous compounds on the distribution of soil fauna.

MYCOLOGY DEPARTMENT

Control trials against Red rust, Black rot and Thorny stem blight were undertaken during the year. Six chemical formulations were tested, namely Orthodifolatan, Brestan 60, Zincop, Fycol 8 ET, Bayer 5191 and Blitox. Studies on the time of spraying against Red rust and Black rot were made. The relationship between shade and nutrients in disease development was continued in collaboration with the Botany department. Aerobiological studies were continued.

Red rust : a) Red rust has been observed to produce and disperse spores in large numbers until early July and therefore it was felt necessary to study the effects of altering the conventional times of spraying. It may be of interest to see the spore dispersal pattern of Red rust and Black rot type for the years 1967 and 1968 and compare the disease incidence and the conventional spraying periods, (see Fig. 1). With this in view, an experiment was laid out in a nearby area having severe red rust infection. The following treatments were applied using pressure retaining hand operated knapsack sprayers.

1. Blitox 0.25% One round in mid May.
2. „ „ Two rounds from mid May at monthly intervals.
3. „ „ Three rounds from mid May at monthly intervals.
4. „ „ Four rounds from mid May at monthly intervals.
5. „ „ Five rounds from mid May at monthly intervals.
6. „ „ Two rounds, one in mid May and the other at the end of May (This is the present conventional method).
7. Control. No spraying.

Assessments were made at two weeks interval from mid June until mid October, see table 1. A sharp natural decline in fructifications on the plant was noticed from mid July.

Table 1 : Mean degree of infection of Red rust per plot of 40 bushes as observed on different dates.

Treatments	18.6.68	2.7.68	19.7.68	30.7.68	14.8.68	24.9.68	17.10.68
1	69.0	87.2	78.2	39.5	25.5	5.5	2.8
2	67.5	47.7	48.2	33.2	20.0	4.3	2.3
3	68.7	53.7	53.2	26.5	17.5	5.3	3.5
4	71.7	57.7	55.2	26.0	16.8	6.5	4.0
5	66.0	52.7	45.0	30.5	13.3	5.3	3.5
6	43.5	63.5	69.7	48.0	23.5	6.8	4.3
7	109.0	105.2	94.2	39.7	19.8	6.5	4.8
C. D. at p=0.05	9.5	16.5	13.0	16.8	Not significant	Not. significant	Not significant
C. V. %	9.1	16.6	13.75	32.5	38.3	29.8	34.6

From the table it is seen that the degree of infection by red rust recorded a fall in all the treatments whether sprayed or unsprayed after the end July. This is because of the organism's commencing the development of its resting stages. By the late September, the alga appears to have almost completely stopped producing spores. From then onwards spores trapped by the modified Derham trap are most probably from alternate hosts.

It was noticed that application of two rounds of Blitox at monthly intervals (mid May and mid June) during the fruiting period gave better control of the disease than the two rounds given during mid May and at the end of May.

b) An area consisting of young tea plants known to be affected by Red rust was selected in a neighbouring garden. Two sprayings were done, using a knapsack sprayer, at fortnightly interval during the prophylactic period (mid and end of May) using Orthodifolatan, Brestan 60, Zincop, Fycol 8 ET, Bayer 5191 and Blitox. Unsprayed plots served as control.

Assessment on the intensity of infection was made on two occasions at monthly intervals in July and August by examining the bushes visually and scoring individual plants, depending on whether the fruiting hairs of the algal parasite were absent, few, moderate, plenty or abundant.

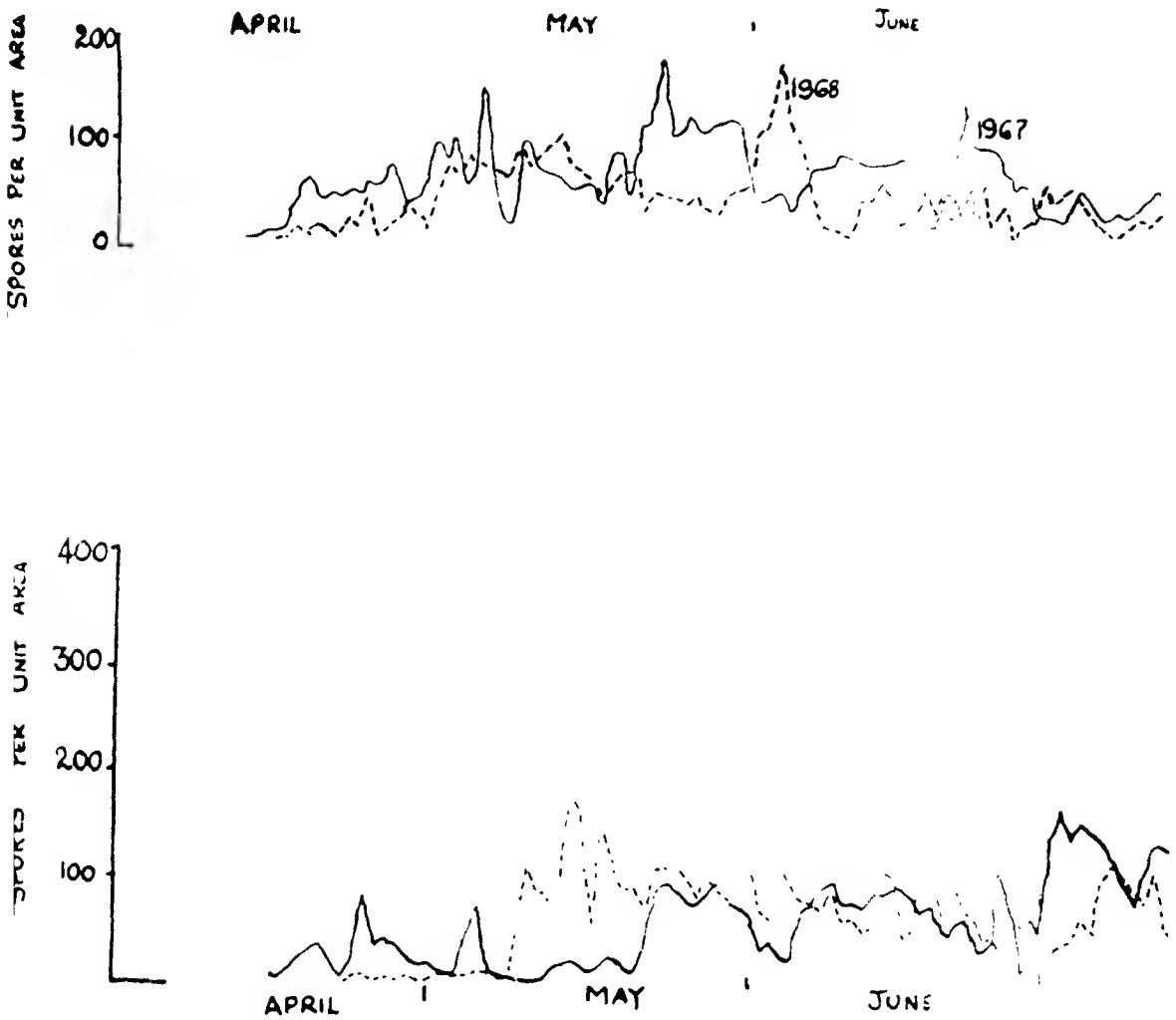


Figure. 1. Showing the pattern of dispersal of Red rust ... Black rot

Blitox registered low Red rust infestation in comparison with the other treatments.

c) Fycol 8 ET an oil based combined formulation of copper oxychloride is claimed to be more persistant than any other copper compound used in rubber plantations. An experiment was therefore laid out using Fycol 8 ET and Blitox in different doses. Fontan type of sprayer was used. This was conducted in collaboration with the P. T. U. Branch and treatments were :-

1. Control - No. spraying.
2. Fycol 2 kg/acre in one application during mid May.
3. Fycol 2 kg/acre in two applications sprayed mid May and mid August.
4. Fycol 2 kg/acre in three applications sprayed mid May, mid July and mid September.
5. Fycol 2 kg/acre in six applications sprayed during the middle of the following months :- May, June, July, August, September & October.
6. Fycol 2 kg/acre in twelve applications- mid May onwards fortnightly.
7. Blitox 2 kg/acre in one application during mid May.
8. Blitox 2 kg/acre in two applications - mid May and mid August.
9. Blitox 2 kg/acre in three applications from the middle of each month - May, July and September.
10. Blitox 2 kg/acre in six applications from the middle of each month- May, June, July, August, September and October.
11. Blitox 2 kg/acre in twelve applications from mid May onwards fortnightly.

The assessments were made at fortnightly intervals, upto the middle of October. No appreciable reduction in the disease incidence was noticed in this first year. The effect of persistence, if any, will be noticeable next season.

Black rot : In an experiment on the North Bank, a comparison was made between the spraying efficiency of a pressure retaining knapsack sprayer which is in general use in tea gardens, and a power sprayer (Fontan). In each, Blitox was used which is a standard copper fungicide against Black rot.

The following treatments were applied on two occasions during the third week of May and early June at an interval of two weeks.

1. Blitox 1 in 400 dilution with knapsack at approximately 4.5 kg/ha (this is the conventional 1 in 400 dilution).
2. Blitox at 2.5 kg/ha with Fontan.
3. Blitox at 4.5 kg/ha with Fontan.
4. Control- No. spraying.

Assessments were made on two occasions during August and September. Crop records were also maintained during the season following fungicidal application. The results are given below in able II.

Table 2. Effect of spraying chemicals on the Black rot incidence and crop yield

Treatment	Mean degree of Black rot incidence per plot		Mean yield in kg. green leaf per plot of 40 bushes
	1st observation	2nd observation.	
1. Blitox 1 in 400 with knapsack.	12.0	20.0	29.5
2. Blitox 2.5 kg/ha with-Fontan.	6.2	14.8	29.6
3. Blitox 4.5 kg/ha with-Fontan.	8.2	11.8	29.0
4. Control- No. spraying.	106.5	111.0	26.9
C. D. at p=0.05	8.8	9.14	2.0
C. V.%	21.6	18.8	5.7

From the above table it can be concluded that fungicidal application efficiently done at the right time results in a high reduction of the disease and greater yield return. Thus 2.5 kg fungicide per hectare with a Fontan is more economical.

A screening experiment against Black rot, during the prophylactic period (which is the third week of April onwards when the organism is growing actively) was laid out on the North Bank with a view to comparing the effectiveness of Blitox, Orthodifolatan, Fycol 8 ET and Brestan 60. These were all sprayed with pressure retaining knapsack sprayers and all at a dilution of 1 in 400 which, approximately amounts to 4 kg/ha of each formulated chemical. Scoring of the incidence of the disease was made on two occasions, once in August and once in September.

All the formulations, at the rates used, caused significant reductions of the disease, but Blitox was significantly superior to others. Results are given in table 3.

Table 3. Mean degree of incidence of Black rot as affected by two rounds of spray using a knapsack sprayer.

	Mean degree of incidence	
	1st observation in 3rd week of August	2nd observation 2nd week of September.
Blitox	7.6	10.4
Orthodifolatan	20.2	25.2
Fycol 8 ET	26.4	23.4
Brestan 60	14.8	20.6
Control- No. spray	43.8	39.6
C. D. at p=0.05	7.9	10.2
C. V. %	26.2	31.8

l. P. K. manuring and its effect on Thorny stem blight :

Assessments were made for the third year in succession to study the ffect of NPK manuring on the development of Thorny stem blight in an xperiment conducted by the Darjeeling Advisory Branch at Sungma 'ea Estate. Results indicate that neither of the NPK treatments offered gnificant reduction of the disease so far. Phosphate manuring however owed a trend in reduction of the disease as in the previous year. Fur- ıer observations will continue.

erobiology

The distribution of Red rust and Black rot type of spores was again udied during the year and results are given in Fig. 1. Spore catches of ed rust and Black rot between the periods of January and April were egligible.

With the onset of the rains, the organisms started active growth. Red ıst spores appeared during the middle of April and continued until the ıd of August and thereafter they declined in numbers. Black rot spores ı the other hand appeared in small numbers until the 9th of May and ached their first peak on 10th May. The last of the peaks appeared ı the middle of September.

By and large the distribution in time of both types of spores was similar that of 1967. This clearly shows that the spores of both the types are spersed into the atmosphere for much longer periods after conventional raying is stopped. These spores can cause infection which will only be en during the next season when symptoms develop.

PESTICIDE DEPARTMENT

RESEARCH AND EXPERIMENTAL

Screening of Pesticides

During the year evaluation of new pesticides was the main activity of the department. Field trials on joint action of acaricides were once again repeated. The control of shade tree pest with new insecticides was undertaken and is reported. Furthermore, a new nematicidal compound was evaluated this year and compared with Nemagon. In addition the data for last two years on the spraying trial to ascertain droplet pattern were collated and are reported.

Acaricides

Prophylactic spraying

It has been established beyond doubt, through repeated trials during the past ten years, that prophylactic spraying is an effective and the most important measure of control against the build up of a potential populations of red spider and other mites. It has also become a 'must' for the efficient control of pests, because increasingly, estates are adopting extended pruning cycles and consequently more and more tea areas are being skiffed or left unpruned. But it is annoying to find that there are still some estates who do not, as a routine, practise prophylactic spraying, but instead they prefer to wait and watch. The unwiseness of this approach is evident from the heavy infestations of red spider which can be seen on some estates in April-May 1969. Other well sprayed estates are clear. Since there is a range of acaricides which have already proved to be good as prophylactic sprays and the availability of these are now assured, there is no justification for not carrying out prophylactic measures as a routine. As can be seen elsewhere in this Report, the loss in crop in one experiment in the Dooars in 1968 due to bad red spider attack accounted for 20 p. c. over the year (and one fifth of the second flush) in comparison with tea treated prophylactically.

During the year some of the new acaricides, Morocide, Trithion, Morestan, Orchex 693N (Tree spray oil) and Malathion were tried as prophylactics. Tedion and Kelthane were used as standards for comparison. The experimental area was located in a section of mature tea and all the acaricides were applied with a mist blower at the rate of 1.25 l/ha, except Orchex 693N (Tree spray oil) and Malathion which were sprayed at the rate of 10 l/ha and 2.5 l/ha respectively. After two months from application, all the chemicals reduced red spider populations significantly It is also interesting to note that Orchex 693N (Tree spray oil) at 10 l/ha and Malathion at 2.5 l/ha were fairly effective and remained active for a period of two months.

Palliative screening trial of new acaricides

New acaricides Acrex, Rospin, C 8514, A 2529, Anthio mixed with Sandovit and few of the already recommended acaricides, such as Rogor and Malathion at higher doses, were evaluated for their effectiveness as palliative sprays. Their application was done by a mist blower with rotary atomiser (Micronette) at the rate of 1.25 l/ha, except Rogor and Malathion which were used at the rate of 2.5 l/ha and 2 l/ha respectively. All the acaricides, except Malathion and Anthio mixed with Sandovit, gave 99% kill of the mites.

Combined spraying trials

For a variety of reasons, two or more compounds having physiological effects on insects are included in many formulations used in the insect control. Firstly, a mixture may be useful in controlling a mixed population of mites and insects if one species is very susceptible to one component and another species to a second. Secondly a special effect such as 'synergism' may make the mixture especially insecticidal, and so permits more economic control of insects than by one active ingredient alone. Thirdly, a combination of a more rapidly acting but less persistent compound with a less rapidly acting but more persistent compound, often seems to be favourable in practice. Fourthly, the combination of acaricidal/insecticidal materials might be useful in preventing the build up of resistant strains of mites and/or insects.

Keeping the above points in view and also because it is a fact that tea bushes in almost all tea growing areas in N. E. India are simultaneously attacked by different mites and insects pests, such as red spider, scarlet, pink and purple mites, scales, thrips and jassids, trials were carried out in Assam, the Dooars, Terai and Darjeeling with different chemicals mixed together in different quantities.

Joint action of acaricides

Field trial No. 1 : A field trial was laid out in a section of a commercial tea estate in the Dooars (Dam Dim T. E.) where red spider, scarlet and pink mites were present. The treatments were applied with a mist blower and the combination of acaricides used with their rates of application were :-

a.	Ethion 4 E	+ Morestan at 0.5 l ha	+ 0.5 kg/ha	respectively
b.	,,	,, at 0.3125 l ha	+ 0.3125 kg ha	,,
c.	Tedion V-18	+ Morocide at 0.5 l/ha	+ 0.5 l/ha	,,
d.	,,	,, at 0.3125 l/ha	+ 0.3125 l/ha	,,
e.	Tedion V-18	+ Trithion at 0.5 l/ha	+ 0.5 l/ha	,,
f.	,,	,, at 0.3125 l/ha	+ 0.3125 l/ha	,,

g. Morestan at 1.25 kg/ha
h. Tedion at 1.25 l/ha
i. Ethion at 1.25 l/ha
j. Trithion at 1.25 l/ha
k. Morocide at 1.25 l/ha

The results were very encouraging. It was found that mixtures of two acaricides, Ethion plus Morestan, Tedion plus Morocide, Tedion plus Trithion when used at the rate of 0.5 l/ha of each were equally effective as when the same chemicals were used singly at their recommended doses, (treatments g to k).

Field trial No. 2 : Another field trial was carried out in Assam (Teok T. E.) in a section of tea where bushes were infested with a mixed population of scarlet, pink and purple mites. The treatments were applied with a mist blower. The combinations of acaricides used and their rates of application were :-

a. Ethion 4 E + Morestan at 0.5 l/ha + 0.5 kg/ha respectively
b. ,, ,, at 0.3125 l/ha + 0.3125 kg/ha ,,
c. Morocide + Ethion 4 E at 0.5 l/ha + 0.5 l/ha ,,
d. ,, ,, at 0.3125 l/ha + 0.3125 l/ha ,,
e. Ethion 4 E + Trithion at 0.5 l/ha + 0.5 l/ha ,,
f. ,, ,, at 0.3125 l/ha + 0.3125 l/ha ,,
g. Morocide + Morestan at 0.5 l/ha + 0.5 kg/ha ,,
h. ,, ,, at 0.3125 l/ha + 0.3125 kg/ha ,,
i. Ethion 4 E at 1.25 l/ha
j. Morocide at 1.25 l/ha
k. Trithion at 1.25 l/ha
l. Morestan at 1.25 l/ha

The results indicated that there was not much difference in effectiveness amongst the mixtures of acaricides used. All were equally effective and most encouraging.

So far the results of these two experiments are encouraging and they suggest that the effects of the joint action of two compatible acaricides mixed together and used against a combined infestation of two or more mites can be effective and economical.

Joint action of acaricides and insecticides

In the foregoing text, the results of mixing two acaricides for the control of combined infestation of mites were discussed. But there are sections

of tea where there are not only combined infestation of different species of mites only but where mites and insects are frequently located at the same time.

Thus it was decided to try the effects of acaricides mixed with insecticides.

Field trial 1 : This trial was conducted in Assam (Teok T. E.) in a section where there was a combined infestation of red spider, scarlet mite and scales. The treatments were applied with a mist blower and the acaricide/insecticide mixture used with their rates of application were :-

a. Morocide + Morestan + Malathion at 0.375 l/ha + 0.375 l/ha + 2.5 l/ha respectively
b. ,, ,, ,, at 0.25 l/ha + 0.25 l/ha + 1.25 l/ha respectively
c. Tedion + Morocide + Malathion at 0.375 l/ha + 0.375 l/ha + 2.5 l/ha respectively
d. ,, ,, ,, at 0.25 l/ha + 0.25 l/ha + 1.25 l/ha respectively
e. Ethion 4 E + Morocide + Malathion at 0.375 l/ha + 0.375 l/ha + 2.5 l/ha respectively
f. ,, ,, ,, at 0.25 l/ha + 0.25 l/ha + 1.25 l/ha respectively
g. Ethion 4 E + Malathion at 1.25 l ha + 2.5 l/ha ,,
h. Tedion + Malathion at 1.25 l/ha + 2.5 l ha ,,
i. Morestan + Malathion at 1.25 kg ha + 2.5 l/ha ,,
j. Morocide + Malathion at 1.25 l ha + 2.5 l ha ,,

The result was very encouraging and it was found that for the control of mixed infestation of red spider, scarlet mite and scales in a section of tea, a combined spray of two acaricides e. g. Morocide plus Morestan, Tedion plus Morocide, Ethion plus Morocide each at 0.25 l ha when mixed with Malathion at 1.25 l/ha can be effectively used.

Field trial 2 : Another trial was conducted in a section of tea in the Terai (Sahabad T. E.) where red spider, purple mite and thrips were present. The acaricide/insecticide mixture were applied with mist blower and their rates of application were :-

a. Ethion + Kelthane + Thiodan at 0.4375 l/ha + 0.4375 l/ha + 1.25 l/ha respectively
b. ,, ,, ,, at 0.3125 l/ha + 0.3125 l/ha + 0.625 l/ha ,,

c. Ethion + Morocide + Thiodan at 0.4375 l/ha+0.4375 l/ha + 1.25 l/ha respectively
d. ,, ,, ,, at 0.3125 l/ha+0.3125 l/ha + 0.625 l/ha
e. Ethion + Thiodan at 1.25 l/ha + 1.25 l/ha respectively
f. Kelthane + Thiodan at 1.25 l/ha + 1.25 l/ha respectively
g. Morocide + Thiodan at 1.25 l/ha + 1.25 l/ha respectively

The results were encouraging and it was found that mixture of two acaricides such as Ethion plus Kelthane, Ethion plus Morocide at 0.4375 l/ha each and an insecticide - Thiodan at 1.25 l/ha were highly effective for the control of a combined infestation of red spider, purple mite and thrips

Field trial 3 : This trial was conducted in a section of Ging tea estate (Darjeeling) where bushes were simultaneously infested with red spider, thrips and scales. The acaricide/insecticide were sprayed with a mist blower and the rates of application were :-

a. Tedion + Ethion + Malathion + Thiodan at 0.375 l/ha + 0.375 l/ha + 1.875 l/ha + 0.625 l/ha respectively
b. ,, ,, ,, at 0.1875 l/ha + 0.1875 l/ha + 1.25 l/ha + 0.3125 l/ha respectively
c. Tedion + Morocide + Malathion + Thiodan at 0.375 l/ha + 0.375 l/ha + 1.875 l/ha + 0.625 l/ha ,,
d. ,, ,, ,, at 0.1875 l/ha + 0.1875 l/ha + 1.25 l/ha + 0.3125 l/ha ,,
e. Tedion + Malathion + Thiodan at 1.25 l/ha + 1.875 l/ha + 0.625 l/ha respectively
f. Ethion + Malathion + Thiodan at 1.25 l/ha + 1.875 l/ha + 0.625 l/ha respectively
g. Morocide + Malathion + Thiodan at 1.25 l/ha + 1.875 l/ha + 0.625 l/ha respectively

The result was encouraging and it was found that the mixture of one acaricide and two insecticides or two acaricides and two insecticides when used as a mixed spray in all doses gave excellent control of red spider, thrips and scales.

Insecticides

Control of canker of shade trees

Shade is essential for growing tea in N. E. India but it is becoming increasingly difficult to establish and maintain shade trees due to pests and diseases. There are hundreds of species of insects which can be responsible for shade tree deterioration but canker, caused by *Agrilus beesoni*, is the worst enemy, widespread in tea growing areas.

Therefore it was decided to carry out a palliative trial with different insecticides for the control of *A. beesoni*. Three species of shade trees *Albizzia chinensis*, *A. odoratissima* and *A. lebbek*, heavily infested with *A. beesoni* were selected for this purpose. The age of the trees varied between 2 and 3 years. The insecticides used were, Endrex 20 E. C., Dieldrex 18 E. C., Thiodan 35 E. C., DDT 50% W. P., Chlordane 75 E. C. and Rogor 30 E. C. and they were each applied at the rate of 2.5 l/ha with a mist blower. A total of four applications were made at weekly intervals during May/June. Observations were made at monthly intervals for a period of one year. Scoring to determine effectiveness of different treatments was based on the following :-

Whether the spread of infection was arrested due to spraying as judged by whether gummy exudation had stopped or not, following spraying.

The result was quite encouraging and all the above mentioned chemicals were equally effective. The percentage recovery of shade trees treated with Dieldrex, Thiodan, Endrex, Chlordane, DDT and Rogor over the untreated plants were 85,78, 76, 75, 73, 72 and 58 respectively.

Helopeltis theivora

Some new insecticides Thiodan, Birlane, Anthio, Bieldrin, Kilval and Zolone were tried this year in comparison with the standard insecticide DDT for the control of *Helopeltis theivora*.

The trial was conducted in Cachar on mature tea in a section which was moderately infested with *Helopeltis theivora* and the chemicals were sprayed at 1.25 l/ha with a mist blower.

The results indicated that all the insecticides were equitoxic and equally effective and better than DDT against *Helopeltis theivora* for a period of 15 days.

Nematicides

Temik 10 G, a new granular formulation, was received this year for comparing its efficacy against Nemagon as a pre-sowing soil application,

and a field trial was carried out in a commercial tea estate. The rates of application tried were, Nemagon at 37.5 l/ha and Temik 10 G at 37 kg/ha.

Analysis of the results showed that the percentage of plants free from root-knot infestation were significantly higher in Nemagon and Temik treated plots than in untreated control and also root-knot indices were significantly lower in the Nemagon and Temik granular treated plots. The number of seedlings which reached plantable size were significantly greater in Nemagon and Temik treated plots than in the untreated control. There was no significant difference in effectiveness between Nemagon and Temik.

Distribution and penetration of air-blown spray fluids

A spraying machine should always be considered in relationship to the problem to be tackled but more often than not, this is not done. Frequently a wrong machine is chosen or a suitable one is badly handled. Sometimes, too, due to practical or economical reasons, a suitable machine is not available.

The object of the majority of our crop spraying is to control pests and diseases. The habits and behaviours of pests in relationship to the attacked bush and time of the year, influence spraying procedure and the choice of equipment. It is a fact that half the battle for successful spraying is knowing the spray "target" i.e. the particular parts of the bush which must be covered by the pesticide. One of the common mistakes made in spraying is to assume that if the bushes are simply sprayed with pesticide, control of pest or disease is assured. This is not so. It is the target on the bush which must be sprayed. However efficient the pesticide has been proved to be in the laboratory, it cannot be effective unless it falls under field condition on to the target. Thus in the field it is very necessary to make the pesticide available in a sufficient quantity, if control is to be achieved. If after spraying, the insect or disease is not controlled, then it may be assumed to start with, that the insecticide has not been made available to the insect. Some indication of the availability of pesticide on a bush can be achieved by measuring for example, spray cover, spray-deposit density and its distribution throughout the target area.

In view of the above, one spraying trial was initiated to ascertain droplet pattern in Assam on Assam *jats* and another on China bushes in Darjeeling. These spraying trials comparing different sprayers-Hōider Harriden, Micronette and Fontan, were carried out on bushes at different stages of pruning, i. e., (a) immediately after pruning (b) after bud break and (c) during the full plucking season. Sample of leaves were examined at three different levels in the bush top hamper i.e. top, middle and bottom. In Darjeeling,

trials were conducted in sections being on extended pruning cycles e. g. sections pruned in 1963, 1964, 1965 and 1966. Thus it was expected that the bushes which were pruned in 1963 had the maximum leaf canopy and were compact in appearance and those in 1966 the least dense foliage pattern.

Flourescent dyes were used as tracing materials to assess whether an adequate cover of pesticides has been obtained on the target area. After spraying and when the bushes were dry, leaf samples were brought to the laboratory for study under an ultra violet ray lamp which cause the dye-stained spray droplets to strongly fluorescent or shine. Droplets of the solvent were readily seen on the sprayed leaves and then positions and patterns noted.

The results show that on bushes in Darjeeling, irrespective of their having a compact canopy during their latter years of the pruning cycle, the performance of all the sprayers, Holder Harriden, Fontan and Micronette on the top surfaces of the upper leaves at all depths is almost the same and satisfactory. But when the lower surfaces of the leaves at various depths in the top hamper, as the compactness of bushes increased the difference between sprayers become more pronounced. The upper leaf was fairly well sprayed with a manipulated Holder Harriden, Fontan and Micronette, but for the middle and low leaf layers of the bushes, there was a marked fall in efficiency of all sprayers especially the unmanipulated Holder Harriden. Even with Holder Harriden when nozzles were directed to the upper and lower sides of the leaf, the efficiency fell. With the Fontan, on bushes pruned in 1963, only 70% of the leaves were sprayed whereas on bushes pruned 1966, 90% of the leaves were sprayed.

The experiments were repeated in Assam on broad leafed and medium leafed type bushes which were annually pruned. The top surfaces of the leaves at all depths in the top hamper were well covered by the Holder Harriden, Fontan and Micronette. each showing roughly the same efficiency. But again when the undersides of the middle and lower layer of leaves were considered, the results show that the Fontan, Micronette and manipulated Holder Harriden are far superior to the unmanipulated Holder Harriden. Thus it was concluded :

a. In China bushes, when the efficiency of Fontan and Micronette is considered, both upper and lower surfaces of the leaves of the top layers of the bushes are fully covered, but when middle and lower layers are considered, the Fontan and Micronette gave less efficient cover of upper and lower surfaces of leaves, but comparatively the Fontan seems to do better than the Micronette.

b. In Assam type bushes the Fontan and Micronette are both equally efficient in spraying the top, middle and lower layers of leaves.

Taints of Made Tea due to Pesticides

Trithion (Croplife), Trithion (Esso), Micothion, Hexathion, Furadan, Gardona 24 E. C. and 75 W. P., Azodrin, Kilval and Zoloue were tested to find out whether they taint made tea when sprayed at recommended doses. None of the chemicals imparted any taint to made tea.

Residues

Field trials were conducted during dry and wet weather conditions to evaluate residues of Morestan and Thiodan.

CERTIFICATION OF PESTICIDES AND HERBICIDES

During the year sixteen new products were received for official testing. Certificate of approval for 8 products were issued and 15 Certificates were renewed.

BIOCHEMISTRY DEPARTMENT

RESEARCH AND EXPERIMENT

Tea Cream

Investigation into the composition of tea cream and its relation to briskness was started towards the latter part of the year.

Several samples of C.T.C. teas were prepared from Dhoolia *jat*, fermenting the leaf for 70, 90, 120 and 150 mins.

50 g of made tea were infused with 1 litre of hot water for 15 mins over a boiling water bath, filtered and cooled. The cream was separated and washed with small quantity of ice cold water by centrifugation and dried in vacuum. The quantity of cream obtained from the above tea samples varied from 7.0 to 7.6 p.c.

It was found that the cream was composed of mainly caffeine, theaflavins, thearubigins and small quantities of epigallocatechin gallate, epicatechin gallate, gallocatechin, catechin, caffeic acid and chlorogenic acid.

On further examination, it was found that the caffeine did not account for the total nitrogen content of the cream thereby showing the presence of some other nitrogeneous compounds. Paper chromatography did not show the presence of free amino acid in the cream. The cream was then hydrolysed with 6 N HCl for 12 hrs on a boiling water bath. The hydrolysate, on chromatographic examination showed the presence of aspartic acid, glutamic acid, serine, alanine and valine. This result definitely shows the presence of soluble protein substances in tea liquor, and thus the earlier observation that water soluble nitrogen in tea liquor is due to caffeine and amino acids only, needs revision.

MANUFACTURING EXPERIMENT

Inactivation of tea enzyme during the drying process

The inactivation of tea enzyme (oxidase) at different stages of drying at 90° - 95°C was studied by measuring oxygen uptake of different samples in a Warburg apparatus using added substrate(catechin).

This study of the oxidase activity of the fermented leaf indicated that about 50 p.c. of the original activity in the fresh leaf was lost during the normal fermentation process. It was further observed that the enzyme activity in the fermented leaf dried for 10, 20 and 35 mins (fully dried) gradually

decreased but was not entirely lost. Considering the enzyme activity of the fermented leaf to be 100, the relative activities in 10, 20 and 35 mins were respectively about 70, 29 and 23. It was thus evident that fully dried teas still retain about one tenth of the enzyme activity of the unprocessed tea leaf. This residual enyzme activity in the made teas might affect the keeping quality according to the moisture content of the tea and the ambient temperatures during storage. A more detailed study is warranted.

Fortification of tea with lysine

Indian diets, which are mainly cereal based, are conspicuously deficient in l-lysine. This is an essential amino acid limiting the utilisation of other amino acids contained in food stuff. Lysine deficiency in diets is one of of the causes of malnutrition amongst grain consuming populations. Because tea is a very popular and cheap beverage, experiments were tried to fortify tea with lysine with the object of giving an adult his daily lysine requirements in 3 to 5 cups of fortified tea.

A number of treatments were tried and the one described below was found the most suitable.

One kg of fresh leaf which usually produces 200g black tea was withered in the usual way. Lysine monohydrochloride solutions of varying concentrations from 0.33 to 13.3 g dissolved in about 30 ml of water were sprayed over the leaf after two C.T.C. cuts and subsequently black tea was manufactured therefrom. Thus 3 g black tea contained 4.5 to 180 mg lysine hydrochloride or 3.6 to 144 mg actual lysine respectively (the purity of l-lysine hydrochloride obtained from U.S.A.I.D. was 90 p.c.)

The teas were tasted by Tocklai, Calcutta and London panels of tasters. All of them agreed that the addition of l-lysine hydrochloride during manufacture did not materially affect the normal characteristics of tea liquor but some reductions of prices in the fortified teas were indicated. Average valuations of the teas produced from one source on different dates are shown in Table 1.

Table 1 Variations of prices (Rs./kg) of the fortified teas as evaluated by the three different Tasting Panels.
(Figures are the averages of three repeats)

Mg lysine per cup (3 g tea in 150 ml water)	Tocklai Taster	Calcutta Tasting Panel	London Tasting Panel
Control	6.13	6.30	11.82
72	5.23	6.40	11.71
108	5.37	6.30	11.55
144	5.27	6.17	11.41
C.V. %	5.69	2.75	1.49
C.D. 5%	0.63	0.35	0.35
1%	0.95	0.52	0.52

The valuations scored by the Tocklai Taster were found to be significantly different for different treatments but for Calcutta and London tasting panels, no significant variation between treatments was found.

Studies on the effect of storage of the treated teas for 4 to 6 months indicated that neither the lysine content in tea nor the liquor characters were destroyed. In fact about 80 p.c. of the lysine content, estimated by paper partition chromatography, is recoverable in the cup of liquor in various methods of preparation of tea as practised in different parts of India.

These experiments were carried out in the Tocklai miniature factory. Experiments to incorporate lysine in larger quantities of leaf under commercial conditions will be conducted next year.

Manufacturing Aid

Experiments relating to the manufacturing aid for the improvement of the overall commercial value of tea continued in the Tocklai pilot factory for the major part of the season using the clones 19/29/13, 20/23/1, 106/1 and 3/77 and Burma *jat*.

Experiments were also conducted in several tea estates in Upper Assam and Cachar, using the aid on greater quantities of leaf under commercial conditions.

The teas were tasted by Tocklai, Calcutta and London tasters. All the tasters preferred the treated teas to the controls, although they differed in degrees in some cases.

MISCELLANEOUS EXPERIMENTS

Theaflavins (TF) and Thearubigins (TR)

In a series of experiments carried out in connection with the method of estimation of TF and TR, it was observed that the total colour (TF + TR) of a tea infusion could be measured directly from the infusion by suitable dilution with methanol and added oxalic acid. The O.D. (at380 mμ) thus obtained was found to be equal to the sum of the optical densities of TF and TR measured separately after their partition from the tea infusion. Thus when the O.D. of TF had been found out by the usual method, the O.D. of TR could be obtained by difference and thereby the method could be simplified.

Further, the sodium bicarbonate used in the method for determining TF, slowly decomposes to carbonate in a tropical climate leading to an anomaly in values of TF that can hardly be avoided. A search was therefore made for a suitable, stable and simple substitute for sodium bicarbonate. Use of tris buffer at pH 8.6 or one per cent anhydrous disodium hydrogen phosphate in place of sodium bicarbonate produced similar results as obtained by Robert's method. Since tris is not available in India, anhydrous disodium hydrogen phosphate can be recommended to replace the usual sodium bicarbonate.

Isolation of theaflavins from tea waste

Experiments relating to the isolation of theaflavins from tea waste (stalk and fluff) was undertaken with a view to make use of this material for enhancement of overall quality of tea. A cheap and quick method has been worked out for isolation of theaflavins.

ADVISORY

Testing of samples

Twenty two experimental samples of Instant tea (soluble tea) prepared by Dr. M. M. Chakrabarty in the Science College, Calcutta University were chemically analysed.

Iced tea drinks manufactured by the Brooke Bond Tea Company and U.S.A. were also tested.

Moisture meters

A number of Kaybee and N-Foss type moisture meters were adjusted and calibrated during the year.

Electronic moisture meters

Moisture meters designed by different firms on electronic principles were sent to us for testing and calibrating. None of them was, however, found suitable.

Touring

The Biochemist visited several tea estates in Upper Assam and Cachar during the year.

Meetings

The Biochemist attended the meeting of the Tea Sectional Committee (AFDC:16) of Indian Standard Institution, New Delhi, in September.

———

MANUFACTURING ADVISORY AND TEA TASTING DEPARTMENT

Leaf carriage

It should be common knowledge that any mechanical damage to the leaf from the time of plucking till it reaches the factory adversely affects the cup characters of the made tea(Annual Report 1967). Besides mechanical damage, development of heat in the bulk of freshly plucked shoots also adversely affects cup characters even though the temperature may not be high enough to render the leaf red.

To reduce heating, some freshly plucked shoots were transported in a leaf trailer covered on all sides but having a water trough at the bottom and a suction fan on the top, the fan being run from the battery of a Jeep used for hauling the trailer. The fan sucked air over the water trough and through the leaf contained in square baskets in the trolley. The trailer was designed and built by the Senior Research Engineer at Tocklai. Leaves contained in standard square baskets were transported in an open vehicle with only a canopy on top. It was observed that by the time the leaf reached the factory from our field experimental station 2½ kilometers away and with a time lag of about half an hour, in the covered trailer fitted with the suction fan, it was about 4-5°F lower in temperature than the leaf carried in the other trailer.

Teas were made from these leaves on six occasions during the rains and the tea made from leaf carried in the covered trailer with suction fan, was definitely superior to the tea made from leaf carried in the ordinary trailer.

This preliminary result, we consider very encouraging and further investigation may give a clue as to the optimum temperature which should be maintained in the bulk of leaf while being carried from field to factory.

Roller Charge

The effect of roller charge on the cup characters of C.T.C. teas was observed during the year. As in the case of orthodox tea, overcharging as well as undercharging, adversely affected the cup characters of the made tea. In N.E. India today, the tendency is to overcharge rollers in C.T.C. manufacture, a tendency which should certainly be avoided during the second flush quality period.

Unpruned tea

Leaf from pruned and unpruned sections, supplied by a commercial estate, was manufactured separately in the miniature factory four times during the month of August. The made teas were sorted and sent to two blenders and a panel of tasters in Calcutta. The assessment of the result showed that the teas from the unpruned sections were inferior

Effects of storage of made tea in cool conditons

Samples of made teas were packed in aluminium containers sealed with cellotape. Some of these samples were kept in a deep freeze, some in an air condition room about 27°C (80°F) and some in the tasting room which had a temperature of anything up to 38°C (100°F) and averaged not less than 32°C (90°F) during the monsoon. These teas were tasted at intervals and results showed that the teas kept in a deep freeze were definitely the best, followed by those kept in the air conditioned room. The tea which was kept in the tasting room was definitely the worst. The results show that temperature has a detrimental effect on the storage potential of made tea and this suggest that transporting tea in air conditioned cool containers would be a good step forward.

Effect of using 10 grooved segments instead of 8 grooved segments in a C.T.C. machine

Teas made with C.T.C. rollers fitted with 10 grooved segments instead of 8 grooved segments were definitely better sized and with brighter liquors but whenever the conditioning roll prior to C.T.C. processing was not adequate, the liquors turned out to be very thin.

Aluminium linings

One of the accepted purposes of using aluminium linings is to prevent the tea from picking the moisture, as well as taints from the tea chest panels. Investigations carried out reveal that there are aluminium linings in the market, some of which are extremely porous. Normally it is said that thicker the linings the less porous it will be, but we feel that the point to stress is the porosity of the linings and not essentially the thickness. The result of a preliminary investigation show that tea packed in linings having about 600 holes per sq metre picked up about 2 p. c. more moisture compared to tea packed in linings having about 160 holes per sq metre and this was in the course of one month in normal Assam temperatures and humidities of the rains.

ADVISORY WORK

Withering : Estates with better withering facilities are definitely able to make harder and brighter teas which are more valuable than the plain teas produced during the rains with inadequate wither.

The trough is the most popular form of artificial withering and more and more estates are installing troughs. Of the two types, open and closed, the open ones are giving much more even and better wither.

As may be expected with artificial withering, leaf damage is more pronounced than with natural withering. Very often estates having artificial withering facilities, wither their leaf to the extent just short of the leaf getting red. From experience it is found that plucked shoots can become red even when the wither is not more than about 80 p. c. so the remedy is not really to aim for a lighter wither but to try to minimise leaf damage from the time of plucking until it reaches the factory.

Conditioning of leaf prior to C. T. C. manufacture : A definite appreciation of the need for conditioning of leaf prior to C. T. C. manufacture has come. The well edges of rollers are being built up to get proper circulation of the leaf. This, I am sure will bring considerable improvements to the teas, particularly those made during the quality period.

Dual manufacture : In dual manufacture the tendency is to extract as much fines as possible to make orthodox tea is declining and the tendency now is to extract about 10—15 p. c. fines and this in my opinion is the correct approach. Sorting of orthodox teas is most important in dual manufacture and the number of orthodox grades should not be more than three under any circumstances and preferably two.

Rotorvane cone : The new Rotorvane cone attachment has given much better results than expected, particularly on estate having inadequate withering facilities. The cone definitely imparts a certain amount of twist, even when the leaf is not very well withered, and as a result, the cut in the C. T. C. need not be very hard. This lighter cut helps to make bright and brisk teas. The feeding of leaf into the Rotorvane still seems to be a problem and no full proof method has yet been devised. The Rotorvane cone attachment however takes care to a large extent of small variations in feed rate.

Fermenting Trough : The fermenting trough has become very popular. Estates having artificial withering are deriving more benefit from the troughs than estates without artificial wither.

Testing of commercial products : 'Clean Wash' detergent powder supplied by Hanumanbux Sitaram, Tinsukia was tried for cleaning fermenting surfaces and found unsuitable for use by the Tea Industry.

Laminated linings for tea chest supplied by Indian Aluminium company Ltd., Calcutta was found to be unsuitable for use as linings for packing of tea.

Tea Tasting : During the season 3,333 experimental samples from Tocklai, 8,898 samples from estates for advising on manufacture, and 9,415 clonal samples from estates were tasted.

Touring : Ninety one factory visits were made for advising on manufacture by the Manufacturing Adviser & Tea Taster. Although the total demand for visits were much more, a number of requests for visits simply could not be complied with. Twelve group tastings were also held; these tasting sessions were well attended and I feel Members benefit by them.

Lectures : Two lecture courses on Factory Management together with demonstrations were conducted by the Manufacturing Adviser & Tea Taster in co-operation with the Biochemistry and Engineering Development Departments.

Meetings : The Manufacturing Adviser & Tea Taster attended seven area Scientific Committee Meetings. He also presented a paper to the Seminar on Protein Fortification of Foods organised by the Association of Food Technologists in Jadavpur University campus, Calcutta.

ENGINEERING DEVELOPMENT DEPARTMENT

RESEARCH AND EXPERIMENT

WITHERING

The findings of the simple stepped trough reported last year, were extended with considerable success to commercial troughs by introducing suitable baffles in the air duct at different points.

ROLLING

Continuous Green Leaf Processing Machines

I. Disc Type Continuous Rollers

(i) 48" Disc Roller

The 122 cm (48") Commercial Prototype Disc Roller was in operation and was being gradually improved throughout the season. Minor adjustments of its operating speeds and orientation of battens gave good make and style to leaf and some improvement in the colour of the tips was also observed. The operating speeds were 24 rpm for the feed screw and 7.5 or 12 rpm for the rotating disc. At these speeds the rate of intake of withered leaf is approximately 1100 kg (2400 lb) per hour.

The discolouration of the tips noticed during the early part of the season gave rise to some doubts regarding the suitability of aluminium as the material of construction for the discs, notwithstanding its successful use in conjunction with C.T.C. method of manufacture. Hence the discs were subsequently lined with 1.6 mm (1/16") brass sheeting. The battens were also newly made from brass sheets of similar thickness. The results showed improved leaf style and tip colour.

Some improvement to the processing action of this roller was brought about by—

(a) adustment of the shape and depth of the battens,
(b) reduction of the speed differential between the feed worm and the rotary disc, and
(c) alteration of the disposition of the end of the feed worm in relation to the discharge end of the cylindrical feed barrel.

The combined effect of these adjustments reflected itself in teas with a comparatively better leaf style and colour of tips. The roller is now proposed to be installed at a commercial tea factory in the neighbourhood of Tocklai.

(ii) **30" Disc Roller**

The 76 cm (30") Prototype Disc Roller was in operation during the season at Ging T.E., Darjeeling. Trials during the early part of the season suggested some alterations of the battens and the operating speeds. Consequently the machine was modified in early August to incorporate the same design features as those of the 122 cm commercial prototype at Tocklai. The roller was found to be producing somewhat improved leaf style after the modification but it appeared that the processing components of this roller needed considerable alteration to suit the requirements of Darjeeling type of leaf and wither. Investigations into the nature of alterations necessary for the purpose had been taken in hand at Tocklai and a mini-Disc Roller was adapted to incorporate the feature which appeared to be desirable in such rollers for use with different types of leaf and wither.

(iii) **Mini-Disc Roller**

Tenders received for commercial manufacture of this machine are being considered by the Tea Research Association, Calcutta. As reported above, efforts are continuously being made at Tocklai to obtain further improvement in the processing action of the Mini-Disc Roller.

II. Continuous Tea Roller; Vertical Type

The 38 cm (15") Vertical Tea Roller was installed at Gandrapara T.E. in the Dooars for trial in conjunction with legg cut method of manufacture. Tasting reports on available samples indicated that this roller gives a better quality of legg-cut tea when compared to the normal double legg-cut/roll tea. The Senior Research Engineer during his visit to Dooars in early August found the machine working satisfactorily but its output to be about 400kg per hour with single cut leaf and about 630 kg per hour with double legg-cut leaf. To improve the throughput of the machine a feed worm of 20 cm (8") pitch and a feed cylinder of 30.5 cm (12") diameter was made at Tocklai. These will replace the existing 15 cm (6") pitch feed worm and 20 cm (8") cylndrical feed barrel of the roller in the next season.

III. Rotorvane

Cone Attachment

The cone attachments for the 15" and the 8" rotorvanes are now commercially manufactured by the Port Engineering Works.

Barbora Leaf Conditioner

Fabrication of a 15 cm (6") short rotorvane consisting of a feed screw, the cone and an adjustable sleeve fitted with a series of studs was completed early in the season. As this machine has no vane and resistor of the type

used in a rotorvane, the term, 'short-barrel-rotorvane', has been abandoned and it is better called a continuous leaf conditioner. Officially it will be known as the Barbora Continuous Leaf Conditioner.

The machine was operated in competition with a 6" standard rotorvane fitted with an iris end plate and a 6" standard rotorvane fitted with a cone attachment on pure rotorvane manufacture, as well as rotorvane/C.T.C. manufacture .

Results indicated that while there was some improvement in the liquor characters of the teas processed in the continuous leaf conditioner /C. T. C. method of manufacture compared to the rotorvane/C. T. C manufacture, there was no appreciable improvement in the liquor characters of the teas processed through the continuous leaf conditioner over the rotorvane in pure rotorvane manufacture. Improved briskness and brightness have been marked by the Tocklai Tea Taster in the teas processed through the continuous leaf conditioner. Summarised results in tabular form showing the comparative values of teas processed in this machine in competition with rotorvane are given in table 1 & 2.

Table 1.

Method of Manufacture :

Treatment 1 = 6" *Leaf Conditioner* 1 *pass* + 2 *cuts C. T. C.*
,, 2 = 6" *Rotorvane with cone* 1 *pass* + 2 *cuts CTC.*
,, 3 = 6" *Rotorvane with cone minus* 14 *resistors* 1 *pass* + 2 *cuts CTC.*
,, 4 = 6" *Rotorvane without cone* 1 *pass* + 2 *cuts CTC.*

Valuations are in Rs. per kg.

Treatment :				Treatment :			
1	2	3	4	1	2	3	4
6.96	6.00	—	—	5.40	6.50	6.00	—
5.87	5.87	—	—	5.17	5.54	5.11	—
6.00	6.17	—	—	5.40	—	6.00	6.50
6.26	5.78	—	—	5.45	—	5.13	5.55
6.05	5.41	—	—	6.00	5.70	—	5.80
5.70	5.53	—	—	5.51	5.56	—	5.30
5.57	5.32	—	—	6.50	—	7.50	5.40
5.18	4.93	—	—	5.46	—	5.62	5.11
6.50	5.60	5.80	—	8.00	—	6.50	5.80
5.34	4.72	5.21	—				
5.80	6.50	5.40	—				
4.96	5.58	4.86	—				

Table 2.

Treatment 5 = 6" *Leaf Conditioner* 2 *passes.*
„ 6 = 6" *Rotorvane with cone* 2 *passes*
„ 7 = 6" *Rotorvane with cone minus* 14 *resistors* 2 *passes.*
„ 8 = 6" *Rotorvane without cone* 2 *passes.*

Valuations are in Rs. per kg.

Treatment : 5	6	7	8	Treatment : 5	6	7	8
5.00	6.00	—	—	4.40	4.90	—	—
5.56	5.07	—	—	5.19	4.87	—	—
5.80	5.37	—	—	5.50	5.80	6.50	—
5.60	5.40	—	—	5.22	5.00	5.53	—
5.91	5.59	—	—	5.30	5.00	5.40	—
5.00	6.00	—	—	4.98	5.12	5.35	—
5.83	6.00	—	—	5.40	—	7.00	6.00
6.26	5.41	—	—	5.55	—	5.29	5.36
5.19	5.68	—	—	4.90	5.00	6.00	—
5.00	5.60	—	—	5.13	5.64	4.22	—
5.60	5.00	—	—	4.90	—	5.00	5.40
5.30	5.12	—	—	4.94	—	5.29	5.31
6.50	6.00	—	—	5.00	—	6.50	6.00
5.23	5.86	—	—				

IV. Tocklai Continuous Roller

The 51 cm (20") prototype Tocklai Continuous Roller, Mark II, fabricated by Britannia Engineering Co., at their Titaghur Works was received by Heeleakah Tea Factory at the end of the 1968 manufacturing season and commercial manufacturing experiments with this roller, projected for the season 1968, will now be taken up in the season 1969. This machine as constructed is an improvement on the Mark I machines previously fabricated by Britannias. The Tocklai fabricated 38 cm (15") T. C. R. Mark II has been returned to Tocklai.

FERMENTATION

Continuous Machine

The 5' Prototype Continuous Fermenting cum Drying Machine was tried out at Duklingia during the early part of the season from the middle of May to the end of July. A 5 ton air conditioner was incorporated in

the machine which enabled the chamber temperature to be kept between 90°F and 98°F D. B. The tray speed was adjusted to allow 40 min. fermentation for C. T. C. processed leaf and 23 min drying at 195°F inlet temperature. Oxygen was injected into the fermenting chamber at the rate of 1 litre per min. In almost all the cases, tea fermented in this machine was preferred by the Tocklai Tea Taster to Duklingia's normal floor fermented teas. The exceptions were few and mostly in the initial stages due to leaf differences and slight faults in firing.

The Tocklai Manufacturing Adviser's comment on these teas was as follows :—

"Teas which have come out better than Duklingia Normal are quite nice teas and they have been fairly well dried."

Towards the end of July the fermenting chamber of this machine was disconnected and completely remodelled as an independent Continuous Fermenting Machine with a variable speed drive. Arrangements are included for recirculation and humidification of the air-stream inside the chamber. The results of the first trials are given in Table 3.

Table 3

Date	Thickness of spread	Wither	Fermentation period in the m/c	Temperature of circulating air			Bulk leaf temperature of fermented leaf at discharge	Rate of feed of oxygen	Tea Taster's remarks
				Dry	Wet	HD			
4.10.68	7.5"	75%	40 mts	86°	85°	1	99°F	1.5 lit/mt	+
5.10.68	6"	75%	40 mts	90°	88°	2	98°F	10 lit/mt	+
9.10.68	6"	90%	45 mts	85°	84°	1	94°F	10 lit/mt	+
10.10.68	6"	90%	50 mts	86°	85°	1	92°F	10 lit/mt	=
11.10.68	6"	90%	55 mts	88°	87°	1	92°F	10 lit/mt	=
12.10.68	6"	90%	55 mts	90°	89°	1	99°F	10 lit/mt	−
15.10.68	6"	75%	55 mts	88°	87°	1	90°F	5 lit/mt	+
16.10.68	6"	95%	55 mts	87°	86°	1	98°F	5 lit/mt	−
17.10.68	6"	90%	50 mts	88°	87°	1	98°F	5 lit/mt	+
18.10.68	6"	90%	50 mts	88°	86°	2	92°F	5 lit/mt	+
19.10.68	6"	85%	45 mts	89°	87°	2	92°F	5 lit/mt	−
22.10.68	6"	80%	45 mts	90°	87°	3	93°F	5 lit/mt	+
23.10.68	6"	80%	45 mts	88°	86°	2	92°F	5 lit/mt	+
24.10.68	6"	80%	37 mts	88.5°	86°	2.5	92°F	5 lit/mt	+
25.10.68	6"	80%	35 mts	90°	89°	1	92°F	5 lit/mt	−
26.10.68	6"	90%	37 mts	90°	88°	2	92°F	5 lit/mt	+
29.10.68	6"	85%	40 mts	88°	86°	2	91°F	5 lit/mt	+
30.10.68	6"	80%	44 mts	88°	86°	2	92°F	5 lit/mt	+
31.10.68	6"	90%	55 mts	87°	84°	3	93°F	5 lit/mt	+
1.11.68	6"	85%	55 mts	86°	85°	1	94°F	5 lit/mt	+
2.11.68	6"	90%	57 mts	86°	84°	2	91°F	3 lit/mt	+
5.11.68	6"	85%	53 mts	88°	86°	2	92°F	3 lit/mt	=
6.11.68	6"	85%	53 mts	85°	82°	3	91°F	3 lit/mt	−
7.11.68	6"	85%	55 mts	88°	86°	2	90°F	3 lit/mt	−
8.11.68	6"	90%	60 mts	88°	85°	3	94°F	3 lit/mt	+
9.11.68	6"	90%	60 mts	90°	89°	1	91°F	3 lit/mt	+

Summary : + Teas from Continuous Fermentation Machine preferred = 18
= No appreciable difference between samples = 4
= Teas from Normal floor fermentation preferred = 4

Total runs 26

The results indicate a distinct trend that good wither and lower temperature of the fermenting leaf is beneficial to the resulting teas. How the temperature of fermenting leaf effects the quality of end products in deep layer fermentation of tea will be a subject matter of investigation with this Continuous Fermenting Machine, towards which, the 5 ton Air-Conditioner purchased for use with the original Continuous Frementing cum Drying Machine is being incorporated in the recirculatory ducting of the new machine.

DRYING

No further work has been taken up with the drying of tea.

MOISTURE CONTENT OF GREEN LEAF

A capacitance bridge and a high stability oscillator having an output of 3 volts A. C. at a frequency of 1 mega cycle to feed the bridge were built in the laboratory of this department. The bridge is now being employed in an attempt to correlate the moisture content of tea with the change of capacitance of the circuit. Previous experiments indicated that to obtain satisfactory results, one more parameter i. e. the weight of a definite volume of tea must be taken into account. Efforts are now being directed to design an instrument, which will take account of all these factors which will give an accurate measure of moisture in tea within acceptable limits. It is hoped that an instrument of this kind will be made ready for trial during the next manufacturing season

PLUCKING MACHINE

Experiments were continued at Borbhetta throughout the last season with the plucking aid operating in competition with shear harvestors and hand plucking An abstract of Borbhetta's report on the performance of the plucking aid against commercial shears and hand plucking is given in Table 4.

Table 4

Treatments : T_1 — *Hand plucking*
,, T_2 = *Commercial shears*
,, T_3 = *Tocklai aid*
,, T_4 = *Tocklai aid followed by hand plucking on the same day to pick up the left-overs.*
,, T_5 = *Commercial shears followed by hand plucking on the same day to pick up the left-overs.*

Treatment	Weight of made tea in kg/hactare	Per cent damage of	
		tender shoot	mature leaf
T_1	512.47	4.3	Nil
T_2	317.06	40.7	5.5
T_3	275.87	60.0	7.6
T_4	392.36	54.9	9.5
T_5	437.94	36.7	7.6

The same trend was noticed at Runglee-Rungliot T. E., Darjeeling, in which a Tocklai Plucking Aid was used in competition with hand-plucking.

The area used was hybrid pruned tea.

Date	By Machine				By Hand			
	No. of bushes	Quantity kgs	Leaf count good	Leaf count bad	No. of bushes	Quantity kgs	Leaf count good	Leaf count bad
3.7.68	100	2.500	51	49	100	2.500	92	8
10.7.68	100	5.000	50	50	100	3.500	80	20
18.7.68	100	2.700	58	42	100	3.000	82	18
26.7.68	100	2.000	53	47	100	2.500	84	16
5.8.68	100	2.100	54	46	100	2.400	86	14
Total	14.300	266	234			13.700	424	76
Average daily		2.860	53	47		2.740	85	15

The Runglee-Rungliot Manager's remarks on the machine is quoted below :

"It can be seen that in its present form the machine is unsuitable as the percentage of acceptable leaf is very poor. It tends to tear off a lot of young shoots as well as any old leaf which comes upto the plucking

table. Its operation is rather tiring and it is felt that what it gains in speed of harvesting, it looses through fatigue of the operator. Time taken to pluck each plot by machine and by hand was about the same."

This criticism was not unexpected as the experimental models fabricated at Tocklai were made of aluminium alloy sheets, and although the weight of the machine was brought down to 1.67 kg each, this dead-weight itself caused an early on-set of fatigue and hence inefficient working of the system. Efforts are now being directed towards finding a willing plastic moulding firm which is prepared to mould, for Tocklai, a limited number of suitable plastic components. Once the dead-weight is cut down to below .5 kg, which is within the realms of possibility with this design, it is expected that the field results will improve considerably.

TOURING

The Senior Research Engineer attended two meetings of the Engineering Sub-Committee at Tocklai and Calcutta and three meetings of the Area Scientific Committees at Tocklai, Tingrai and Darjeeling. He also visited Britannia Engineering Co. on three occasions and Port Engineering Co. Works at Howrah on one occasion in connection with the fabrication and manufacture of commercial versions of Tocklai Machines. The Senior Research Engineer represented the Association at a meeting of the Indian Standards Institution at Bombay on I. S. I. Building code for tea factories.

Advisory visits were paid to thirty estates during the year in addition to the routine visits to factories where Tocklai machines were under commercial proving trials.

STATISTICS DEPARTMENT

Help to Other Departments

During the year, the Department extended intensive co-operation and help in solving more than seventy statistical problems encountered by research workers of different Departments of the station in relation to experiments with agriculture, biochemistry, entomology, mycology, manufacturing and tasting of tea samples. Out of those, twenty-nine problems were solved using an IBM electronic computer at the Indian Institute of Technology, Kanpur. In order to analyse these long-term experimental data on the electronic computer, a number of FORTRAN programmes were prepared during the year. Two programmes which were prepared last year to analyse the data of the C5 project were further improved to increase the efficiency of calculations on the computer.

Statistical Study of the Chemistry of Tea

A critical study of the results obtained from statistical analyses of data of the project C5 of the Biochemistry Department (Tocklai Annual Scientific Rep., 1967-68, pages 99-100) suggested the presence of joint effects of some of the significant chemical factors which were highly correlated amongst themselves on Briskness, Quality and Valuation of made teas. Accordingly, an attempt was made to find out the relative contributions of those chemical factors and their interactions towards Briskness, Quality and Valuation scores of made teas for each taster separately during the year.

The computer results so far decoded, reveal the presence of significant joint effects of some of the chemical factors on Briskness, Quality and Valuation of made teas.

Detailed results will be published gradually in, "Two and A Bud".

Survey of Shade Trees

To study the influence of various shade species on the incidence of individual pests or diseases on tea bushes, the severity of infestation of individual pests or diseases was observed during the rainy season (19.7.65 to 27.9.65) on a sample of tea bushes under each shade species in six circles; namely, Nowgong, Jorhat, Nazira, Dibrugarh, Naharkatia and Panitola of the Assam valley.

Estimated percentage areas of tea bushes affected by all pests and diseases under various shade species were presented earlier (Tocklai Annual Scientific Rep., 1967-68, pages 101-102) by circles. Detailed analysis of the data by individual pests or diseases is given in Table 1.

It is seen from Table 1 that the estimated percentage areas of tea bushes affected by a particular pest or disease varied between circles within species and between species within circle. Over the circles, percentage area of tea bushes affected by red rust was found to be maximum (12%) under *Albizzia odoratissima* and minimum (2%) under *Dalbergia assamica*. The corresponding percentage areas of tea bushes affected by branch canker and black rot were found to be maximum (12% and 4% respectively) under *Albizzia chinensis* and that of red spider under *Albizzia procera* (9%). On the other hand attacks of branch canker and red spider were found to be minimum (5% each) under *Dalbergia assamica* whereas black rot was minimum (2%) under *Albizzia odoratissima*. In general, tea bushes under *Dalbergia assamica* were found to be less affected by individual pests or diseases.

To study the rate of growth with age of different species of shade trees under the conditions prevailing in the above six circles, girth of a shade tree was measured at 122 cm height from the ground level and spread of foliar canopy was measured as the mean radius from the trunk. Analysis of the data is being continued.

Long-term Survey-Experiments on Defoliation

A long-term survey-experiments on defoliation was laid out by the Department in the Dooars in 1963 with the following objectives (Tocklai Annual Rep., 1963, page 94) :

'To study the long-term effect of continuous defoliation *vis-a-vis* other control measures on the yield of mature tea, incidence of red spider and other pests, and the economic gains, or losses as a result of continuous defoliation.'

There are six replications and each has been divided into two parts for two main plot treatments (Tocklai Annual Scientific Rep., 1965, pages 118–119). With effect from the 1967/68 cold weather, main plot treatments; namely, Annual Prune, and Prune-Prune-Deep Skiff have been changed to Prune-Deep Skiff, and Prune-Deep Skiff-Medium Skiff respectively in view of the fact that there has been a general change over from annual pruning to prune-deep skiff cycle as well as longer cycles in the Dooars. Hence, all the plots were deep skiffed during the 1967/68 cold weather because they were pruned during 1966/67 cold weather season. Under each main plot treatment there are six sub plot treatments which are listed below :

1. **Control (untreated) :** No defoliation and no chemical spraying.

2. **Defoliation only** : By hand

3. **Chemical prophylactic spraying only :** This is done with one round of Tedion V-18 E.C. (8%) as soon as the first sign of red spider infestation becomes visible but not later than the 15th March in any case.

4. **Chemical palliative spraying only :** This is done with one round of Tedion V-18 E.C. (8%) when approximately 30 p.c. of the bushes are affected by red spider. A second application may be applied after a month if the red spider reappears and approximately 30 p. c. of the bushes are affected. In no case is it given within one month of the first application.

5. **Defoliation and chemical palliative spraying :** A combination of treatments 2 and 4.

6. **Chemical prophylactic and palliative spraying :** A combination of treatments 3 and 4.

The peak period for red spider infestation was found to be during April and May in both the years 1967 and 1968

Since the start of the actual treatments in 1964 until the 1968 season, red spider infestation was very low in all the plots and in 1967 maximum tea bush areas affected by red spider was found to be 7 p. c. only in the control (no defoliation and no chemical spraying) plots during April and May. But in 1968 for the first time, red spider attack was severe and all the control plots were severely attacked except one which had a mild attack. However, red spider was controlled satisfactorily in all the treated plots. Since defoliation or chemical prophylactic spraying controlled red spider satisfactorily, chemical palliative spraying was not necessary in treatments 5 and 6. Hence, the six treatments in the experiment virtually reduced to four during 1968 see Table 3). Similarly during 1967 when the red spider infestation was very low, practically no chemical palliative spraying was necessary in treatments 4, 5 and 6 and there the six treatments virtually reduced to three treatments (see Table 2a).

Yield data collected during 1967 and 1968 were analysed during the year and the treatment means, corrected for vacancies and pretreatment yields, are given in Tables 2a, 2b, and 3.

It is interesting to note from Table 2a that defoliated plots for the first time since the start of the experiment gave significantly lower yield than the control (untreated) plots and because the red spider infestation was low during 1967 and previous years, this decrease in yield might in fact be due to defoliation. Again, no significant difference in yield was observed between the control and the chemical prophylactic plots. Hence, a yield

Table 1. Estimated percentage area of tea bushes affected by individual pests or diseases under different species of shade; by circles.
(Period of observation : 19.7.65 to 27.9.65)

Species of shade trees	Circle	Estimated percentage area of tea bushes affected by :				
		Red rust	Branch canker	Red spider	Black rot	Looper caterpillar
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Albizzia odoratissima	Nowgong	15.6	21.9	0	0	0
	Jorhat	15.3	11.5	6.8	1.6	3.0
	Nazira	12.5	11.5	5.5	0.8	0
	Dibrugarh	0.4	0.1	6.0	2.8	0
	Naharkatia	6.0	4.6	7.0	3.0	0
	Panitola	1.9	1.2	8.0	5.1	0
	Over-all	11.7	11.2	5.3	1.8	1.1
Albizzia procera	Nowgong	.....Not Observed			.....	
	Jorhat	10.0	12.9	7.4	0.3	0
	Nazira	12.8	17.2	8.9	1.6	0
	Dibrugarh	1.3	0.4	11.7	6.2	0.04
	Naharkatia	7.5	5.5	7.0	3.4	0
	Panitola	1.7	1.4	7.9	5.7	0.12
	Over-all	6.2	7.1	8.9	3.4	0.03
Albizzia chinensis	Nowgong	20.1	24.1	0	0	0
	Jorhat	12.3	20.1	11.7	3.7	2.9
	Nazira	4.8	5.1	5.7	0.3	0
	Dibrugarh	0.9	0.3	12.1	7.5	0
	Naharkatia	7.8	5.8	5.9	1.0	0
	Panitola	2.9	1.3	8.4	6.0	0
	Over-all	9.5	12.0	7.8	3.5	0.8
Dalbergia assamica	Nowgong	.....Not Observed.....				
	Jorhat	4.2	11.7	7.3	0	0.9
	Nazira	4.3	9.9	0.04	0.6	0
	Dibrugarh	0.01	0.4	6.2	3.3	0.1
	Naharkatia	4.9	3.9	7.8	2.6	0
	Panitola	1.4	1.3	5.9	4.0	0.3
	Over-all	2.4	4.6	5.1	2.3	0.2

N. B. An estimate obtained from any sample survey is subjected to sampling error. Therefore, 'Zero' estimates presented in the table do not mean that all the tea bushes are completely free from the pests or diseases.

Table 2a: Mean yield of made tea in kg/ha during 1967

Sub-plot Treatments		Yield
A : Control	[1+4]	1861
B : Defoliation	[2+5]	1753
C : Chemical Prophylactic	[3+6]	1831
Critical Difference at 5%		94
C. V. (%)		9

Table 2b: Mean yield, made tea in kg/ha, of defoliated and undefoliated plots during 1967

Sub-plot Treatments		Yield
Defoliated	[B]	1753
Undefoliated	[A+C]	1846
Critical Difference at 5%		81

Table 3 : Mean yield of made tea in kg/ha during 1968*

Sub-plot Treatments		Yield
A : Control	[1]	1619
B : Defoliation	[2+5]	1878
C : Palliative	[4]	1970
D : Chemical Prophylactic	[3+6]	2026
Critical Difference for comparing A and C at 0.1%		304
Critical Difference for comparing B and D at 5%		122
Critical Difference for comparing A or C and B or D at	5%	149
	1%	200
	0.1%	263
C. V. (%)		10

* : Means are based on five replications because one replication which is on Hope T. E. could not be plucked as the estate was on strike for most of the season.

comparison between the defoliated and undefoliated (control + chemical prophylactic) plots was made which showed that the defoliated plots gave significantly lower yield than the undefoliated plots (Table 2b). These results suggest that continuous defoliation has a detrimental effect on the yielding capacity of the tea bushes.

During 1968, when the attack of red spider was severe on the deep skiffed tea, all the treated plots where control measures were taken against red spider; namely, defoliation or chemical prophylactic or chemical palliative, gave significantly higher yields than the badly attacked control plots which were neither defoliated nor sprayed with chemicals. The increase in yield due to the control of red spider by defoliation, chemical palliative or chemical prophylactic spraying was found to be 16 p.c. (259 kg of made tea/ha), 22 p. c. (351 kg of made tea/ha) and 25 p. c. (407 kg of made tea/ha) respectively over the control plots (Table 3).

Further, though each of the three treatments; namely, defoliation, chemical prophylactic and chemical palliative spraying controlled red spider satisfactorily, the yield of the defoliated plots was found to be significantly lower than the undefoliated plots which received only the chemical prophylactic spraying and that loss was about 7 p. c. (148 kg of made tea/ha) over the undefoliated chemical prophylactic sprayed plots (Table 3). As in 1967 this loss may be attributed to the detrimental effect of the continuous defoliation for five years. Again, the lower yield in the defoliated plots as compared to the undefoliated but chemical palliative sprayed plots was found to be not significant. This might be explained by the fact that palliative spraying was not done until approximately 30 p.c. of the bushes were affected by red spider (Table 3).

The above results suggest that if any prophylactic measure against red spider is intended, chemical prophylaxis would be better than complete defoliation of the tea bushes.

The statistical analysis of the red spider infestation data collected during 1968, as opposed to yields mentioned above, is still in progress.

The experiment will be continued to study the objectives outlined above.

Touring and Advisory

The Statistician and two members of the Department visited the Indian Institute of Technology, Kanpur in connection w th the statistical analyses of data from long-term and complex experiments on the IBM electronic computer. The Statistician also visited the Indian Statistical Institute, Calcutta during the year. Three members of the Department visited Bokahola T.E. weekly in connection with the uniformity trial there. Mr. D. K. Sanyal, Statistical Assistant, attended a course on electronic computer methods at the Indian Statistical Institute, Calcutta from 21.10.68 to 18.1.69.

LIBRARY AND PUBLICATIONS DEPARTMENT

LIBRARY

General

The Library subscribes to 120 scientific journals published in India and abroad. Due to the rapid increase in the subscriptions of foreign scientific journals only six extra journals could be added to the library this year. We are also getting 105 journals free, or on exchange for our own publications.

Loan Service

A total of 450 publications was issued to the different departments of the Station and 690 publications were consulted in the library.

10 Scholars from the Assam Agricultural College (now the Agricultural University) M. Sc. Class, about 12 scientists of R. R. L., Jorhat and one scientist from Uganda utilised the library during the year over and above the nine T. R. A. trainees. Several Officers of the Government of Assam also collected certain data from the library.

Documentation Service

Weekly accession lists were circulated to all the departments of Tocklai and to the Outstations. Classification works are in progress but catalogue and index cards could not be typed owing to shortage of staff.

About 175 pages of scientific documents were photocopied by the library and distributed to research departments.

Book Preservation

Experiments in 1959–61 in the library revealed that paris green was more effective than zinc phosphite for killing rats and most of the rats in the library were killed during the year. Cockroaches were removed from the library a few years ago by spraying D. D. T. But the bookworms, like silver fishes, are abundent in most of the old books. Spraying Gammaxene powder inside the pages of the books has not been done because of it toxicity to humans. Creasote oil and napthaline powder is now being mixed into the glue used for binding books.

Due to the excessively hot and humid climatic conditions in the Assam monsoon, books and other documents deteriorate very quickly and moulds and fungi grow easily and abundantly. It is therefore very desirable that

the library stack and reading rooms should be air-conditioned as soon as is possible to preserve the most valuable agricultural library in Assam against the deterioration it is now suffering.

Book Binding

A total of 236 books were bound during the year and it is expected that some old and worn out books will be rebound next financial year.

Library Statistics

Books added during the year	- 169
Periodicals & Journals	- 2231
Pamphlets	- 652
Photocopies	- 6
Microcopies	- 7
Reprints	- 141
Translations	- 1

PUBLICATIONS

The publication section was kept busy during the year due to publication of several Soil Survey Reports and other new publications and new subscribers to our publications increased considerably.

The following publications were issued by the Station during 1968/69.

(1) "Two & A Bud" (Newsletter) Vol. 15, Nos. 1, 2, 3 & 4.
(2) Annual Scientific Report for 1967/68.
(3) Summarised Annual Scientific Report for 1968 (restricted circulation)
(4) Tocklai occasional Scientific Paper No. 2, Soil Survey 1967/68 'Results for the Dooars and Terai areas'.
(5) Tocklai Occasional Scientific Paper No. 3, Soil Survey 1967/68 'Results for the Darjeeling District'.
(6) Tocklai Occasional Scientific Paper No. 4, Soil Survey 1967/68 'Results for the Cachar District'
(7) A Report on a Visit to the Netherlands under International Technical Assistance Programme by B. Banerjee (restricted circulation).
(8) Report on a visit to the United Kingdom and Kenya - by R. Choudhury (restricted circulation).

Tea Encyclopaedia Serials (Revised)

(9) 10/4 Pruing of Young tea in the plains of N.E. India.
(10) 108/2 Tea Seed Nurseries.
(11) 9/5 The Manuring of Young Tea.

Tea Encyclopaedia Serials (New)

(12) 173 Rotorvane/C.T.C. Manufacture.
(13) 174 Operation and Maintenance of Power Sprayers.
(14) 175 Double Hedge Planting.

J. N. Sharma
Librarian and Publication Incharge

APPENDIX A

List of Experiments
conducted in the Member Estates
by
the Advisory Department

South Bank, Assam

Project	Site	Index	year of starting
Rehabilitation of land	Sangsua	AS 45	1963
	Duklingia	AS 48	1964
	Ghillidary	AS 49	1964
	Hansara	AS 50	1964
N P K Manuring	Murmuria	AS 11	1956
	Khoomtaie	AS 29	1959
	Katonibari	AS 44	1963
	Hunwal	AS 51	1964
	Dirok	AS 63	1965
	Ghillidary	AS 88	1968
	Hunwal	AS 92	March 1969
Nitrogenous fertiliser	Sycotta	AS 56	1964
	Sagmootea	AS 62	1965
	Joonktollee	AS 64	1966
	Nahorhabi	AS 65	1966
	Furkating	AS 69	1966
	Halmirah	AS 71	1966
	Cinnamara	AS 77*	1966
	Meleng	AS 78*	1966
	Borsillah	AS 79*	1966
	Joonktollee	AS 82	1967
	Gabroo Purbut	AS 83	1967
Pruning	Cinnamara	AS 12	1957
	Duklingia	AS 13	1958
	Dufflating	AS 84	1967
	Nahorhabi	AS 90	1968

Project	Site	Index	year of staring
Cultivation & weed Control	Cinnamara	Short Term Trials	1965
	Katonibari		1969
	Dessoie		1969
	Sotai		1968
Irrigation	Amluckie	AS 52	1963
	Borahi	AS 67	1966
	Gorunga	AS 68	1966
	Gabroo Purbut	AS 70	1966
	Dejoo Valley	AS 72	1966
	Dejoo Valley	AS 73	1966
Jat and Clonal trial	Nagajanka	AS 89	1968

*Effect of nitrogen with and without liming.

North Bank, Assam

Project	Site	Index	Year of starting
Rehabilitation of land	Tarajuli	AN 46	1964
	Deckiajuli	AN 47	1964
N P K Manuring	Borjuli	AN 85	1968
	Dekorai	AN 87	1968
Nitrogenous fertiliser	Halem	AN 3	1933
	Nahorani	AN 59	1964
	Gingia	AN 80*	1966
	Hatigor	AN 91	Jan. 1969
Pruning	Phulbari	AN 58	1964
	Ghoirallie	AN 60	1965
	Kolony	AN 76	1966
Irrigation	Balipara	AN 55	1963
	Sessa	AN 61	1965
	Durrung	AN 74	1966
	Mazbet	AN 75	1966
Cultivation and Weed Control	Halem	AN 15	1958
	Halem	AN 31	1960

* Effect of nitrogen with and without liming.

Cachar, Assam

Project	Site	Index	Year of starting
Rehabilitation of land	Koomber	C 25	1964
N P K Manuring	Isa Bheel	C 26	1966
	Hattikhira	C 27	1966
	Longai	C 28	1966
	Silcoorie	C 32	1967
Nitrogenous fertiliser	Pallorbund	C 29	1966
	Dewan	C 30	1966
Pruning	Coombergram	C 21	1961
	Longai	C 22	1962
	Chandighat	C 23	1962
	Pallorbund	C 33	1967
	Dewan	C 34	1967
	Derby	C 35	1968
Irrigation	Roopacherra	C 31	1966
Shade and Manuring	Coombergram	C 20	1962
	Koomber	C 36	1968

Dooars & Terai, West Bengal

Project	Site	Index	year of starting
Rehabilitation of land	Bhogotpore	D 27	1964
	Grassmore	D 28	1964
N. P. K. Manuring	Kalchini	D 1	1964
	Nedam	D 30	1963
Nitrogenous Fertilizer	Baradighi	D 33	1966
	Bhatpara	—	1966
	Gopalpur	—	1968
	Dem Dima	—	1968
	Chengmari	—	1968

Project	Site	Index	year of starting
Pruning	Chuapara	D 2	1955
	Baradighi	D 4	1959
	Sam Sing	D 34	1966
Irrigation	Gopalpur	D 35	1966
	Ranicherra	D 36	1968
	Rajabhat	D 32	1968
	Tirrihannah	TR 1	1968
Cultivation and Weed Control	Chuapara	D 10	1957
Shade & Manuring	Nya Sylee	D 24	1962
Shade	Nya Sylee	D 9	1958
Infilling	Kartick	—	1969
	Jainti	—	1969
	Fagu	—	1969
	Hilla	—	1969
	Dem Dima	—	1969
	Sahabad	—	1969
	Mohurgong	—	1969

Darjeeling, West Bengal

Project	Site	Index	Year of starting
N. P. K. Manuring	Tumsong	DJ. 22	1965
	Sangma	Dj. 23	1965
Nitrogenous Fertilizer	Singell	Dj. 26	1966
	Marybong	Dj. 28	1966
	Lingia	Dj. 29	1967
	Bannockburn	—	1968
	Badamtam	—	1968
Pruning	Lingia	Dj. 21	1963
	Phoobsering	Dj. 24	1965
	Goomtee	Dj. 25	1966
	Margaret's Hope	Dj. 27	1966

Project	Site	Index	Year of starting
Plucking	Mim	Dj. 18	1961
Shade & Manuring	Nagri Farm	Dj. 19	1961
Shade & Manuring	Nagri Farm	Dj. 19	1961
Green fly Vs. Flavour	Tumsong		1967
	Gielle	—	1967
	Chamong	—	1967

APPENDIX B

List of Experiments
Conducted in the Member Estates
By
the Other Departments

Agriculture Department

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started
1.	Rehabilitation trial with grasses & cover crops	South Bank, Assam	Hunwal T. E.	S. 1	1966/67
2.	Rehabilitation trial with grasses by manuring	,, ,,	,,	S. 2	1966/67

Botany Department

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started
1.	Trial of biclonal seed stocks	South Bank, Assam	Hapjan	AS 200	1963
2.	,,	,,	Tengpani	AS 201	1963
3.	,,	,,	Tengpani		1965
4.	,,	,,	Kakajan	AS 206	1966
5.	,,	North Bank, Assam	Nahorani	AN 202	1963
6.	,,	,,	Sonabheel	AN 203	1964
7.	,,	,,	Durrung	AN 204	1965
8.	,,	,,	Bhootea-chung	AN 205	1965
9.	,,	Cachar, Assam	Jellalpore	C 200	1963
10.	,,	,,	Dewan Group of estates	C 201	1966
11.	,,	Dooars, West Bengal	Sathkyah	D 200	1962
12.	,,	,,	Bhatkawa	D 201	1962
13.	,,	,,	Bhatkawa	D 206	1965
14.	,,	,,	Hantapara	D 202	1964

	Experiment	Location of Estate	Site (T. E)	Index No	Year started
15.	Trial of biclonal seed stocks	Dooars, West Bengal	Meenglass	D 203	1964
			Hasimara	D 204	1964
16.	,,		Rydak	D 205	1965
17.	,,				
18.	,,	Terai, West Bengal	Hansqua	TR 200	1968
19.	,,	Darjeeling, West Bengal	Mim	Dj 200	1961
20.	,,	,,	Ging	Dj 201	1965
21.	Effect of shade and nutrients	South Bank, Assam			
22.	Observation plots	,,	Murmuria	AS 207	1965
23.	,,	,,	Bazaloni		1962
24.	,,	North Bank, Assam	Duklingia		1963
			Nonaipara		1966
25.	,,	Terai, West Bengal	New Chumta		1963
26.	,,	North Bank, Assam	Budlapara		1967
27.	,,	Dooars, West Bengal	Meenglass		1968

Entomology Department

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started
1.	Ecology and distribution of scarlet mite under Darjeeling conditions	Darjeeling, West Bengal	Ging Tukvar Chongtong Balasun	N 7	1968
2.	Bionomics of scarlet mite under the Dooars conditions	Dooars, West Bengal	Kalchini Ranicherra Telepara	N 7	1968
3.	Distribution of red spider under Cachar conditions	Cachar, Assam	Derby Serispore Aenakhall	N 7	1968

Experiment	Location of Estate	Site (T. E)	Index No.	Year started
4. Incidence of scarlet mite under different agricultural operations	South Bank, Assam	Bokahola	N 7	1967
5. Comparative ecology of tea mites	South Bank, Assam	Murmuria	N 7	1966
6. Bionomics of shade	South Bank, Assam	Duklingia Meleng	N 8	1969

Mycology Department

Experiment	Location of Estate	Site (T. E)	Index No.	Year started
1. To study the effect of altering the conventional time of spraying against red rust	South Bank, Assam	Cinnamara	MR 001	1968
2. To study the persistence of an oil based formulation and also to see the effect of spraying a standard formulation in divided doses and to compare it with the oil based one against red rust.	,,	,,	MR 002	1968
3. Screening of chemicals against red rust	,,	Gabroo-purbut	MR 003	1968
4. Screening of fungicides against black rot	North Bank, Assam	Majuli	MR 001	1968

	Experiment	Location of Estate	Site (T.E)	Index No.	Year started
5.	Comparison between the spraying efficiency of a power sprayer (Fontan) and the pressure retaining knapsack sprayer against black rot	North Bank, Assam	Ghoirallie	MR 002	1968
6.	Effect of Potash manuring (Collaboration-W. Bengal Adv. Dept) on control of black rot.	Dooars, West Bengal	Baradighi	MR 003	1967
7.	Effect of NPK manuring and (Collaboration-Botany Dept.) on black rot, red rust and Poria	South Bank, Assam	Murmuria	BAS204 MBRC	1966
8.	NPK Manuring and its effect (Collaboration Darjeeling Adv. Br.) on incidence Thorny blight	Darjeeling West Bengal	Sungma	MC 002	1966
9.	Screening of fungicide against Thorny blight	Darjeeling, West Bengal	Happy Valley	MC 001	1965
10.	Control trial with different fungicides against purple root rot	North Bank, Assam	Baghmari	MP 001	1965

Pesticide Department

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started
1.	Red spider Prophylactic spraying	South Bank, Assam	Dufflating	—	1968
2.	,,	,,	Dessoie	—	1968
3.	,,	,,	Sotai	—	1968
4.	Red spider screening trial	,,	Deha	—	1968
5.	Joint action of acaricides and insecticides for control of scarlet mite, purple mite and scale insects	,,	Teok	—	1968
6.	Joint action of acaricides and insecticides for control of Red spider, scarlet mite and scale insect	,,	Teok	—	1968
7.	Joint action of acaricides for control of scarlet, pink and purple mite	,,	Teok	—	1968
8.	Joint action of acaricides and insecticides for control of purple mite, scales and thrips	Darjeeling, West Bengal	Tukvar	—	1968
9.	Joint action of acaricides and insecticides for control of Red spider, scales and thrips	,,	Ging	—	1968

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started
10.	Joint action of acaricides for control of Red spider, scarlet and pink mites	Dooars, West Bengal	Dam Dim	—	1968
11.	Joint action of acaricides and inscticides for control of Red spider, purple mite and thrips	Terai, West Bengal	Sahabad	—	1968
12.	Cockchafer pro-prophylactic trial	Dooars, West Bengal	Dam Dim	—	1968
13.	Helopeltis trial	Cachar, Assam	Silcoorie	—	1968

Engineering Department

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started
1.	Continuous Fermenting cum Drying Machine at Duklingia	South Bank, Assam	Duklingia	E & 3 4	Up to 31.7.68
2.	Continuous Fermenting Machine	-do-	Duklingia	E 3	From 1.9.68
3.	20" T. C. R. Experiment at Heeleakah	-do-	Heeleakah	E 2	**
4.	Vertical Roller Experiment	Dooars, West Bengal	Gandrapara	E 2	May, 1968
5.	30" Disc Roller Experiment	Darjeeling, West Bengal	Ging	E 2	October, 1968
6.	Manual Plucking Aid	-do-	Rungli-Rungliot Soom	E 8	1968
		South Bank, Assam	Borbhetta	E 8	1968

** The experiment was projected for the year but due to non-receipt of the T. C. R. from Britannia Engineering Co. it was held in abeyance.

Statistical Department

	Experiment	Location of Estate	Site (T.E)	Index No.	Year started
1.	Uniformity trial	South Bank, Assam	Bokahola	—	1963
2.	Uniformity trial	Darjeeling, West Bengal	Nagri Farm	—	1964
3.	Long term defoliation experiment	Dooars, West Bengal	Nya Sylee	—	1963
			Bhogotpore	—	1963
			Jiti	—	1963
			Hope	—	1963
			Kurti	—	1963

APPENDIX C

PUBLISHED PAPERS AND PAPERS IN THE PRESS

1. Banerjee, B & Kakoti, N. N. (1968). Biology, Pouplation cycle and control of *Ragmus importunitas* Distant. *Indian J. of Entomolgy*, **30**(4) 257–262

   (Abs. The mirid bug, *Ragmus importunitas* Distant severely infests *Crotalaria anagyroides* which is grown for soil rehabilitation purposes in the tea plantations of North-East India. This insect has five nymphal stages and its life cycle is completed in 16 – 24 days. Different instars can be diagnosed from the measurements of body parts, body colours and conspicuousness of wing pads. The population in the field reaches its peak in April – May and then starts to decline until the following January, after which the population starts to increase until the April - May peak is again reached. The pest can be controlled by spraying Dieldrin, Endrin, DDT, BHC or Ekatin, all of which are equitoxic. Some problems on its population cycle and control operations are discussed.)

2. Bezbaruah, H.P. (1968). Cytology of Wilson's Camellia (*C. irrawadiensis* Barua). *Curr. Sci.* **37**(21), 624–625

   (Abs. Investigation on the cytology of Wilson's *Camellia, C. irrawadiensis* Barua which was described from Tocklai Experimental Station, Jorhat, revealed that, like the other Camellia species, Wilson's *Camellia* is also a diploid with basic chromosome number n =15 and 2n =30.)

3. Bezbaruah, H.P. (1968). An evaluation of preparatory procedures for leaf-tip chromosome spreads of the tea plant (*C. sinensis*). *Stain Technology* **43**(5), 279–282

   (Abs. Well-spread metaphase plates for routine karyotype analysis can be obtained by treating the very young leaf-buds of tea shoots in a saturated aqueous solution of p-dichlorobenzene for 2–3 hr at 4–10°C, fixing in a 1:3:6 mixture of propionic acid, chloroform and ethanol for 6-12 hr, staining with 2% propiono orcein at about 80°C, and squashing in a drop of 1% propiono-carmine under a coverslip.)

4. Bezbaruah, H.P. (1968). Genetic improvement of tea in North-East India – Its problems and possibilities. *National Symposium on Accelarating Improvement of India's plant Resources (New Delhi)*

(Abs. The populations of cultivated tea in North East India are highly heterogenous. It is not only a crosspollinated, self sterile crop but a complex compatibility system also exists between the plants. The present paper briefly reviews the experimental approach and achievements in improving tea during the last three decades at Tocklai Experimental Station, and considers the objectives and methods for future breeding programme.)

5. Bhatia, I. S. and Ullah, M.R. (1968). Polyphenols of Tea IV-Qualitative and quantitative study of the polyphenols of different organs and some cultivated varieties of tea plant. *J. Sci. Fd. Agric.* **19**(9), 535–542

(Abs. A method is described for the estimation of individual polyphenols of tea leaf. Polyphenols separated by two-way paper chromatography of a methanolic extract of the material were located under ultra-violet light. The excised spots were eluted with water and estimated from extinctions at 275 nm. Three of the plyphenols, (—) -epigallocatechin gallate, (—) epigallocatechin and (—) -epicatechin galllate, which comprise 10–19% of the dry matter of tea shoots from Assam, are partly consumed during the manufacture of black tea. Seasonal variation in the polyphenolic content of some *jats* and clones grown in North East India are described. The phenolic content of the tea shoots was higher during rains. Changes in the phenolic pattern during the growth and development of tea flower, fruit and seed are described. Organs of tea, such as sepals, petals and pericarp with closer morphological affinities to the leaf, showed a greater degree of similarity in their phenolic pattern compared with other organs such as stigma, style, carpel, anther and testa. The gallates were mostly confined to the chlorophyl-bearing organs.)

6. Hadfield, W. (1968). Leaf Temperature, Leaf Pose and Productivity of the Tea Bush. *Nature* **219**(5151), 282–284

(Abs. It is shown that the Assam type of tea with its large horizontal leaves has a relatively low productivity because not enough light is transmitted to deeper layers of the canopy for a high rate of photosynthesis while in full sunlight photosynthesis in the upper leaves is reduced by overheating. When overheating is prevented by shade, photosynthesis is restricted by the reduced light intensity. This explains why improvement in the level of management of tea plantations in northeastern India has not

resulted in a corresponding increase in yields. A contributory factor is that wind speeds in north-eastern India are gencrally too low to prevent overheating of upper leaves.)

7. Dutta, S.K. (1968). Chemical Control of Weeds in N.E. India. *Proceedings of the 9th British Weed Control Conference* (1968)
(Abs. The weeds of the tea estates have been classified as Grassy areas *Mikania* or *Borreria* areas and General Weeds. In grassy areas spraying of Delapon and Gramoxone has been recommended. In *Mikania* or *Borreria* areas spraying of Simazine 50W & Gramoxone have given good results, for General Weeds spraying of Gramoxone is recommended.)

8. O. Talibudeen and S. K. Dey, "Potassium reserves in British Soils. I. Rothamsted Classical Experiments", *J. Agric Sci. Camb* (1968), **71** p. 95–104
(Abs. Thirty-four soils from the Rothamsted Experiments were exhaustively cropped with ryegrass in the glasshouse. The concentration and yield of potassium in ryegrass tops and the potassium intensity in the soil were measured every 4 weeks, after harvesting the grass.

The change in K-intensity of soils, rich in potassium, with exhaustion differed from that of 'poor' soils. This change was related to the rate of change of the cumulative K-yield. The rate of change of soil K-intensity demarcated periods of intense and limited exhaustion and partial recovery of the soil during cropping.

The cumulative K-yield of ryegrass was very significantly related to the K-intensity of the uncropped soil; the '16-week' yield was slightly better related than the '60 week' yield. For Park Grass soils, the relationship was improved by allowing for variations in soil pH.

The K-intensity of all soils, with or without manuring, decreased to nearly 10–3 $(M)\frac{1}{2}$ in $(AR)_0$ units after 16 weeks cropping, although large differences in K-yield persisted until much later.

K-buffer capacity per unit clay content of the soil, measure by a laboratory method, was inversely related to the K-intensity of the uncropped soil. The K-buffer capacities of soils rich in potassium, measured in laboratory and glass-house experiments,

were significantly related, but were unrelated for 'poor' soils. The K-buffer capacity (laboratory method) of Rothamsted soils with different manurial treatments was only very approximately related to the cumulative K-yield.

Less K was taken up from all Rothamsted soils given nitrogen fertilizer in the field and their K intensities were also smaller than the corresponding soils without 'N'. Field liming of acid soils decreased their K-intensity and increased their K-buffer capacity, presumably because more potassium was removed by the field crop.

A rapid method is suggested for measuring potassium intensities of soils)

9. O. Talibudeen and S. K. Dey, "Potassium reserves in British Soils II. Soils from different parent materials " *J. Agric. Sci., Camb.* (1968), **71,** p. 405–411.

(Abs. Twenty-six soils from different parent materials were exhaustively cropped with ryegrass in the glasshouse. Soil and crop measurements revealed inter-relationships similar to those observed with Rothamsted soils (Part I) generally, except that 12 of 20 soils, 'poor' in K (as defined by the K intensity of the uncropped soil and the change in soil K intensity with cropping), gave patterns of K uptake by the ryegrass crop similar to those of soils 'rich' in K. This indicates that these soils contain some K reserves not differentiated from those accumulated by K-manuring in Rothamsted by laboratory measurements.

The cumulative K yield of ryegrass was very significantly related to the K intensity of the uncropped soil. The relationships were improved slightly by allowing for differences in soil pH and organic carbon content. The cumulative K yields at 16 weeks and at 60 weeks were better related to the total clay ($<2\ \mu$) content than to the fine caly ($<0.2\ \mu$) content of the soil . The K intensities of the cropped soil decreased to nearly 10–3 (AR) units after 16 weeks cropping (except the Harwell soil which took 3 years to do so), although large differences in yield persisted until much later.

Potassium-buffer capacity per unit clay content of the soil (by a laboratory method) was inversely related to the K intensity of the uncropped soil and to K uptakes at 16 and 60 weeks. The reasons for this apparent anomaly are dicussed and a more

correct basis for the units for K-buffering capacity is suggested. The buffer capacities of 'rich' soils in the laboratory and glasshouse experiments were significantly related but not of 'poor' soils.

Soils exhausted by cropping released more K to ryegrass after a drying-and-wetting cycle in amounts proportional to the clay content of the soil. This points to the need for caution in measurements to assess status after air-drying soils.)

10. Banerjee, B. Aggregating behaviour of the caterpillars of *Andraca bipunctata* Wlk. *Science and Culture* (communicated)

11. Banerjee, B. Life cycle studies on *Polydesmus angustus* Latzel. *Jour. Zool. Lond.* (communicated)

12. Banerjee, B. Dynamic of termite populations – Some theoretical considerations. *Ins. Soc.* (communicated)

13. Banerjee, B. & Das, S. C. Effect of the changes on light on the oviposition rhythm of the Tea Red spider mite *Oligonychus coffeae* Nietner. (communicated)

14. Sarkar, A. R. Use of double sampling in estimating the infestation of Red spider, *Oligonychus coffeae* (Nietner), on the tea crop. (communicated)

Appendix—D.

Summary of meteorological observations during 1968

Table 1: Tocklai (Mid Assam) Latitude : 26° 47' N, Longitude : 94° 12'. E, Altitude : 86.6 metres a. m. s. l.

Month 1968	Daily temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
									Depth				
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	open pan in mm	Penman in mm
January	22.0	11.3	16.6	24.6	7.7	43.1	11	5.7	18.8	18.4	19.2	38.3	59.9
	(22.4)	(9.2)	(15.8)			(20.9)	(5)	(5.8)	(19.0)	(18.4)	(19.0)		
February	23.0	11.4	17.2	27.1	7.0	8.2	2	6.6	19.8	19.2	19.6	53.7	78.0
	(24.0)	(11.8)	(17.9)			(32.6)	(7)	(6.1)	(20.7)	(19.8)	(20.2)		
March	27.3	15.7	21.5	30.8	11.9	75.4	13	7.1	23.9	22.8	22.8	90.6	126.0
	(27.5)	(15.4)	(21.4)			(82.7)	(11)	(6.6)	(24.1)	(23.0)	(23.0)		
April	27.7	18.9	23.3	33.5	13.2	299.4	16	6.6	26.1	23.4	24.8	99.7	141.6
	(28.7)	(18.8)	(23.8)			(189.8)	(17)	(5.8)	(27.0)	(25.8)	(25.6)		
May	28.9	21.8	25.4	34.3	19.4	333.5	19	4.9	28.6	27.5	27.4	92.3	149.8
	(29.9)	(21 7)	(25.8)			(286.8)	(21)	(4.9)	(28.5)	(27.5)	(27.4)		
June	31.3	24.4	27.8	34.8	22.0	350.8	20	4.8	31.0	29.4	29.2	100.8	153.9
	(31.5)	(24.0)	(27.8)			(325.4)	(23)	(4.4)	(30.5)	(29.4)	(29.2)		
July	31.0	25.0	28.0	34.1	23.7	508.4	26	3.4	30.9	30.0	29.9	80.0	137.3
	(32.2)	(24.5)	(28.4)			(387.0)	(25)	(4.8)	(31.4)	(30.4)	(30.4)		
August	32.0	25.2	28.6	35.7	23.8	334.2	21	5.0	31.6	30.5	30.6	91.9	154.1
	(32.0)	(24.5)	(28.2)			(339.8)	(23)	(5.0)	(31.4)	(30.5)	(30.4)		
September	31.1	24.6	27.8	33.3	23.1	238.9	22	4.5	30.7	30.0	30.0	77.6	127.5
	(31.2)	(23.8)	(27.5)			(253.8)	(19)	(5.0)	(31.0)	(30.2)	(30.2)		
October	29.7	20.8	25.2	31.5	17.8	167.7	12	6.6	28.4	27.8	28.2	72.3	121.8
	(29.3)	(20.8)	(25.0)			(117.0)	(12)	(5.5)	(28.6)	(28.0)	(28.2)		
November	27.4	15.3	21.4	28.4	12.0	0.5	1	7.4	24.4	23.8	24.5	47.8	85.4
	(26.2)	(15.0)	(20.6)			(26.8)	(4)	(6.0)	(24.2)	(23.6)	(24.6)		
December	24.6	9.2	16.9	28.2	6.9	0.0	0	7.6	19.5	19.0	20.2	37.8	63.3
	(23.3)	(10.6)	(17.0)			(10.4)	(3)	(5.8)	(20.2)	(19.8)	(20.7)		

Note :- (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1968

Table 2 : Silcoorie (Cachar) Latitude : 24° 50' N, Longitude : 92°48' E, Altitude : 39.6 metres a. m. s. l.

Month 1968	Daily temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth			open pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	26.1	11.1	18.6	28.2	7.7	15.3	3	8.0	21.6	20.0	21.5	63.0	76.3
	(26.1)	(11.0)	(18.6)			(20.9)	(2)	(8.0)	(21.5)	(20.8)	(21.4)		
February	27.3	13.2	20.2	29.5	7.2	30.2	3	7.9	23.9	22.5	22.5	91.6	99.0
	(27.2)	(12.9)	(20.0)			(50.5)	(4)	(7.9)	(23.3)	(22.1)	(22.4)		
March	30.8	16.6	23.7	34.7	13.1	79.1	9	8.1	27.0	25.4	25.3	123.1	151.7
	(30.5)	(16.5)	(23.5)			(98.9)	(8)	(7.9)	(26.6)	(25.2)	(25.2)		
April	31.4	20.1	25.8	35.5	13.1	150.4	12	7.9	29.5	27.8	27.3	122.0	168.3
	(32.3)	(20.5)	(26.4)			(211.8)	(12)	(7.9)	(29.7)	(28.2)	(28.1)		
May	30.4	22.0	26.2	35.5	19.6	618.2	22	5.2	29.0	28.0	28.1	110.3	151.8
	(31.8)	(22.7)	(27.2)			(415.7)	(20)	(6.3)	(30.3)	(29.2)	(29.1)		
June	31.4	24.4	27.9	34.3	21.0	488.8	25	4.2	30.7	29.7	29.3	101.1	143.1
	(31.5)	(24.4)	(27.9)			(602.7)	(25)	(4.0)	(30.4)	(29.5)	(29.4)		
July	31.8	25.1	28.4	36.3	24.1	673.9	28	4.5	31.3	30.3	30.2	106.4	155.0
	(32.1)	(25.0)	(28.6)			(541.1)	(27)	(4.5)	(31.3)	(30.4)	(30.3)		
August	32.0	24.9	28.4	34.6	22.3	584.0	27	4.7	31.4	30.6	30.6	103.5	151.4
	(32.2)	(25.0)	(28.5)			(422.8)	(25)	(4.8)	(31.4)	(30.6)	(30.5)		
September	31.4	24.5	28.0	34.3	22.5	284.0	18	5.0	31.0	30.1	30.1	96.6	134.8
	(32.3)	(24.5)	(28.4)			(351.3)	(18)	(5.5)	(31.2)	(30.4)	(30.4)		
October	31.9	22.3	27.1	34.3	19.0	120.8	8	7.2	30.2	29.5	29.5	96.2	136.4
	(31.1)	(22.4)	(26.8)			(215.9)	(11)	(6.5)	(29.4)	(28.9)	(29.0)		
November	29.6	17.5	23.6	30.9	14.6	14.3	3	7.2	26.0	25.4	26.0	69.4	99.4
	(29.3)	(17.0)	(23.2)			(14.7)	(2)	(8.0)	(25.9)	(25.6)	(26.0)		
December	27.5	12.2	19.8	30.7	8.6	0.0	0	7.8	22.5	22.1	23.0	60.5	79.8
	(27.0)	(12.6)	(19.8)			(8.8)	(1)	(7.9)	(22.7)	(22.3)	(23.0)		

Note :- (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface

Summary of meteorological observations during 1968

Table 3 : Nagrakata (Dooars) Latitude : 26° 54' N; Longitude : 88°55' E; Altitude : 228.6 metres a.m.s.l.

Month 1968	Daily temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth 5 cm	Depth 15 cm	Depth 30 cm	open pan in mm	Penman in mm
January	22.1	10.1	16.1	25.0	7.0	10.2	1	6.1	17.9	18.2	19.4	71.5	59.1
	(24.0)	(10.5)	(17.2)			(11.3)	(2)	(8.4)	(18.0)	(17.9)	(19.4)		
February	23.7	11.3	17.5	27.9	7.5	0.3	1	6.9)	19.1	19.3	19.8	91.7	88.1
	(26.0)	(13.4)	(19.7)			(25.0)	(3)	(7.7)	(20.2)	(19.6)	(20.8)		
March	29.2	16.1	22.6	32.2	12.4	30.4	5	7.8	21.6	21.4	21.2	172.3	150.4
	(29.1)	(16.2)	(22.6)			(50.1)	(5)	(7.7)	(23.5)	(22.8)	(23.4)		
April	31.3	19.4	25.4	36.0	13.3	115.6	10	7.3	26.4	26.4	26.6	189.6	172.2
	(31.4)	(20.1)	(25.8)			(109.1)	(9)	(7.3)	(27.0)	(26.1)	(26.4)		
May	30.4	21.4	25.9	31.5	16.3	407.1	21	6.3	27.9	27.5	27.8	146.1	164.8
	(31.0)	(21.7)	(26.4)			(278.7)	(19)	(6.6)	(28.4)	(27.6)	(28.0)		
June	30.1	23.1	26.6	33.1	21.5	931.1	27	3.3	28.4	28.3	28.0	117.0	127.7
	(30.5)	(23.3)	(26.9)			(394.0)	(26)	(3.8)	(28.6)	(27.9)	(28.2)		
July	30.2	23.7	27.0	32.9	22.4	1,123.5	27	2.8	28.3	28.4	28.2	129.6	127.2
	(30.3)	(23.7)	(27.0)			(1,040.2)	(27)	(3.5)	(29.0)	(28.2)	(28.6)		
August	31.2	23.7	27.4	33.6	22.0	708.1	28	4.6	29.8	29.6	29.4	103.6	141.5
	(30.5)	(23.7)	(27.1)			(782.0)	(28)	(4.0)	(29.2)	(28.7)	(28.9)		
September	30.2	23.1	26.6	35.0	21.8	622.9	22	4.1	28.6	28.3	28.9	102.1	119.9
	(30.7)	(22.8)	(26.8)			(527.1)	(22)	(5.5)	(29.0)	(29.0)	(28.8)		
October	29.7	17.6	23.6	31.9	14.5	453.7	8	8.8	25.2	25.2	25.5	127.1	131.2
	(29.8)	(19.5)	(24.6)			(163.5)	(10)	(7.8)	(26.9)	(27.5)	(27.4)		
November	27.8	14.3	21.0	30.8	12.1	2.8	1	8.9	22.4	23.1	23.9	84.0	97.1
	(27.2)	(14.5)	(20.8)			(14.7)	(3)	(8.6)	(22.4)	(22.7)	(24.0)		
December	25.7	10.1	17.9	28.8	6.6	0.0	0	9.1	19.0	19.4	20.8	78.6	76.0
	(24.8)	(11.8)	(18.3)			(4.6)	(2)	(8.4)	(19.6)	(19.7)	(21.0)		

Notes :- (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1968

Table 4: Nagri Farm (Darjeeling) Latitude : 26°55' N; Longitude : 88°12' E; Altitude : 1158.2 metres a.m. s.l

Month 1968	Daily temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth			open pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	13.6 (15.6)	7.0 (8.0)	10.3 (11.8)	17.1	5.0	21.6 (21.6)	9 (2)	4.8 (6.8)	12.5 (13.1)	11.6 (12.6)	13.6 (13.9)	33.6	53.2
February	14.4 (17.3)	7.7 (9.9)	11.0 (13.6	20.0	5.2	8.5 (19.0)	3 (3)	5.1 (6.2)	13.2 (14.8)	12.0 (13.9)	13.2 (14.6)	47.5	64.0
March	20.9 (20.6)	12.7 (12.7)	16.8 (16.6)	24.9	9.0	70.6 (64.6)	4 (5)	6.3 (6.8)	19.4 (18.4)	17.1 (17.1)	17.4 (17.3)	92.9	117.3
April	23.4 (23.4)	15.7 (15.8)	19.6 (19.6)	30.6	10.3	70.3 (81.8)	7 (9)	5.9 (6.0)	23.4 (21.4)	20.5 (20.1)	20.6 (20.0)	110.1	136.2
May	24.0 (23.8)	17.3 (17.1)	20.6 (20.4)	27.0	14.4	170.7 (191.5)	14 (19)	6.2 (5.3)	24.8 (23.4)	22.4 (22.0)	22.4 (21.9)	98.8	146.8
June	23.7 23.9)	18.5 (18.8)	21.1 (21.4)	26.9	16.8	480.4 (405.7)	24 (25)	2.5 (2.8)	24.8 (24.4)	23.7 (23.3)	23.2 (23.2)	59.2	108.6
July	23.8 (24.0)	19.2 (19.2)	21.5 (21.6)	26.9	18.4	522.5 (691.1)	31 (26)	1.9 (2.5)	25.1 (24.6)	23.0 (23.7)	23.6 (23.7)	53.9	110.5
August	25.0 (24.5)	19.2 (19.1)	22.1 (21.8)	28.0	18.0	475.1 (504.5)	26 (26)	3.8 (3.2)	26.2 (25.0)	23.8 (24.0)	24.6 (24.1)	66.0	119.7
September	23.9 (24.3)	18.6 (18.3)	21.2 (21.3)	28.1	17.0	246.7 (316.5)	20 (20)	2.6 (4.3)	25.0 (24.2)	24.3 (23.2)	25.2 (23.4)	52.2	92.8
October	22.5 (23.0)	14.8 (15.5)	18.6 (19.2)	25.4	12.6	749.5 (81.6)	7 (8)	7.9 (6.7)	22.8 (21.8)	19.7 (21.1)	20.5 (21.7)	76.8	108.5
November	17.2 (20.0)	10.4 (11.7)	13.8 (15.8)	22.3	11.0	0 (14.9)	0 (3)	7.4 (7.1)	19.0 (17.7)	17.5 (17.2)	19.2 (18.4)	45.1	69.5
December	18.7 (17.3)	9.4 (9.2)	14.0 (13.2)	21.2	5.9	0 (3.6)	0 (1)	8.5 (6.8)	15.5 (14.6)	13.9 (14.1)	16.2 (15.5)	53.5	61.3

Note :- (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Per cent Relative humidity

Table 1(a) Tocklai

Hours of observations I. S. T.	Jan.	Feb.	Mar.	A pl.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.
0613	96 (97)	93 (95)	91 (93)	90 (91)	92 (93)	92 (93)	94 (94)	93 (95)	95 (96)	96 (97)	96 (97)	95 (97)
1313	59 (58)	48 (55)	48 (55)	62 (63)	72 (71)	73 (75)	78 (75)	75 (75)	78 (75)	67 (72)	58 (64)	51 (61)

Table 2(a) Silcoorie

Hours of observations I.S.T.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
0619	97 (98)	97 (96)	93 (93)	91 (90)	93 (91)	95 (95)	96 (95)	96 (95)	97 (95)	98 (97)	98 (97)	98 (98)
1319	45 (46)	39 (44)	41 (43)	53 (54)	71 (68)	75 (76)	76 (75)	74 (74)	75 (72)	65 (68)	60 (55)	48 (48)

Note :— Data in brackats show previous averages.

Table 3(a) : Nagrakata

Hours of observations I.S.T.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
0634	86	80	71	73	87	95	97	97	96	84	84	85
	(82)	(80)	(74)	(75)	(87)	(95)	(96)	(95)	(95)	(88)	(84)	(86)
1334	59	46	40	47	72	81	86	84	82	62	56	48
	(50)	(50)	(47)	(52)	(70)	(83)	(84)	(82)	(78)	(67)	(59)	(55)

Table 4(a) : Nagri Farm

Hours of observations I.S.T.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
0637	75	76	68	68	80	91	93	94	90	70	59	63
	(70)	(70)	(64)	(68)	(80)	(93)	(94)	(94)	(89)	(77)	(70)	(71)
1337	77	75	61	65	80	84	88	86	87	73	57	61
	(69)	(66)	(62)	(68)	(82)	(90)	(91)	(88)	(86)	(81)	(76)	(73)

Note :- Data in brackets show previous averages.